EFFECTS OF CLIMATE VARIABILITY ON WATER AND PASTURE AVAILABILITY IN TURBI DIVISION OF MARSABIT COUNTY, KENYA.

By

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DECLARATION

Declaration by Candidate

This is my original work and has not been presented for a degree award in this or any other university or any other award.

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DEDICATION

To my wife for the care and support.

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Above all, I'm sincerely grateful to God for His power, guidance and providence. I thank Him for granting me wisdom, knowledge and good health.

I wish to acknowledge my wife for her strong moral and financial support and my children who endured long time of their dad's absence from home.

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ACRONYMS AND ABBREVIATIONS

ACTED	:	Agency for Technical Cooperation and Development
ASALs	:	Arid and Semi-Arid Lands
CBO	:	Community-Based Organisations
CCAFS	:	CGIAR Research on Climate Change, Agriculture and Food Security
CDC	:	Conservation Development Centre
CDF	:	Constituency Development Fund
CETRAD	:	Centre for Training and Integrated Research for ASAL Development
CEWARN	:	Conflict Early Warning and Response Network
COP	:	Conference of Parties
DRR	:	Disaster Risk Reduction
EMCS	:	Environmental Management Committee
ESARO	:	UNICEF Eastern and Southern Africa Regional Office
ESRI	:	Environmental Systems Research Institute
FAO	:	Food and Agriculture Organisation
FGD	:	Focus Group Discussions
GDP	:	Gross Domestic Product
GHA	:	Greater Horn of Africa
GIS	:	Geographic Information System
GoK	:	Government of Kenya (Republic of Kenya)
GROOTS	:	Grassroots Organizations Operating Together in Sisterhood
IBLI	:	Index-Based Livestock Insurance
ICT	:	Information Communication Technology
IEW	:	Institute of Environment and Water
IGAD	:	Intergovernmental Authority on Development
IIED	:	International Institute for Environment and Development
ILRI	:	International Livestock Research Institute
IPACC	:	Indigenous Peoples of Africa Coordinating Committee
IPCC	:	Intergovernmental Panel on Climate Change
IWRM	:	Integrated Water Resource Management
KACCAL	:	Kenya Adaptation to Climate Change in the Arid Lands
KES	:	Kenya Shillings

KMD	:	Kenya Meteorological Department
KNBS	:	Kenya National Bureau of Statistics
KU	:	Kenyatta University
MAM	:	March – April – May
NCCRS	:	National Climate Change Response Strategy
NDVI	:	Normalized Difference Vegetation Index
NEMA	:	National Environment Management Authority
NGOs	:	Non-Governmental Organisations
OND	:	October – November - December
SDGs	:	Sustainable Development Goals
SDt	:	Standardised Deviates
SEI	:	Stockholm Environment Institute
SID	:	Society for International Development
SPI	:	Standardized Precipitation Index
SPSS	:	Statistical Package of Social Science
UNFCCC	:	United Nations Framework Convention on Climate Change
WRMA	:	Water Resource Management Authority
WUAs	:	Water Users Associations

ABSTRACT

Water is life and the heart for existence in the biosphere. Where water is magnanimously plentiful, people and ecosystems thrive in abundance but in places where it is scarce, complex adaptation strategies and sophisticated civilizations have been born. Indigenous systems such as pastoralism have for centuries been flexible to harsh conditions of water and pasture scarcity but exogenous factors like climate change render them fragile. Currently, severe and abrupt changes in climatic conditions have caused serious negative impacts on availability of water and pasture. The overall objective of the study was to establish pastoralist adaptation strategies to the impact of climate change on water and pasture scarcity in Turbi Division of Marsabit County. Specifically, the study compared traditional and conventional strategies of coping with water stress and pasture scarcity under climate variability. The parameters examined were temperature and rainfall. Data was collected between September and November 2016. Primary data was collected using empirical tools. Survey questionnaires were used to collect data from two hundred and three (203) households. These were selected through stratified and simple systematic sampling methods. Additionally, interview schedules with nine key informants, four Focus Group Discussions (FDGs) and field observations were done. Data was analyzed both quantitatively and qualitatively using Statistical Package for Social Sciences (SPSS). Data is presented using graphs, tables and pie charts. Independent variables were examined where inter annual variability was calculated using standardized deviates (SDt) and averaged to show that minimum temperature had increased $\Delta T_1 = +0.243$ ($R^2 = 0.1078$) and maximum temperature had increased $\Delta T_2 = +0.002$ ($R^2 = 0.0003$) and rainfall had reduced $\Delta M_1 = -0.054$ ($R^2 = 0.0005$) and the proportion for communities was $\Delta T_3 = 0.1675$, $\Delta M_2 = 0.4384$ and therefore change in climate (ΔT, $\Delta M \neq 0$). The study found that climatic changes including rainfall patterns 55%, temperatures 21%, sunshine intensity 15% and 9% through changes in cloud cover had been witnessed by 78.3% of the residents through a number of indicators like increased distances to watering points 24%, degraded pasturelands 22%, loss of livestock 18% inter alia as well as extreme conditions like severe droughts 66%, moderate rainfalls 23%, and floods 7% among others. The study established that 4% result to social issues mainly hunger, conflicts and displacement at a ratio of 20:7:4 subsequently influencing adaptation strategies. Using cluster analyses dependent variables showed that there were adaptation strategies clustered as traditional $Y_1 < 1.975$; conventional $Y_2 < 1.403$; challenges in adaptation $Y_3 < 0.759$; intervention from external forces $Y_4 < 1.065$ and therefore that (Y_1, Y_2, Y_3 and $Y_4 \neq 0$). The study concluded that the strategies are interlinked and cyclic. Climate variability should be continuously assessed to embrace future opportunities and address uncertainties. The study recommend that more appropriate and timely adaptation strategies be informed across time and space targeted at unifying the accessibility, affordability and utilization of water and pasture resources in the most sustainable manner with special focus to the local communities.

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

The impacts of climate change are being experienced at both global and regional level (Arnell, *et al.*, 2014; IPCC, 2007; NEMA, 2006). The productivity and sustainability of Sub-Saharan Africa's environment is heavily dependent on how climate change is managed. The Greater Horn of Africa's (GHA) pastoralist areas along the border shared by Ethiopia, Kenya and Somalia are severely impacted by recurrent droughts, storms and diseases (Hany & Nelson, 2009). Kenya is experiencing climate change and variability and associated adverse impacts. Temperatures are rising in some parts while rainfall reduces in others (GoK, 2010a). According to Doti (2010) the country has been faced with droughts that have been linked with climate change and variability. One of the most salient feature in Marsabit County is droughts that are characterized with long periods of water scarcity and continued unproductivity of the land (Doti, 2010; Shisanya, 2005). These conditions are also associated with climate change particularly establishing water as the key contributor to land productivity.

Pastoralism has been described as a sustainable livelihood system. Coping with water and pasture scarcity has been traditionally viable. Climate change is likely to worsen the aridity of the pastoral rangelands and affects a number of resources such as water, pasture and the edible fruits that pastoralists depend on. Conventional strategies to cope with water stress and pasture scarcity result as an adaptation strategy to climate change. Therefore, there is need to determine conventional adaptation strategies and their associated challenges in the study area.

1.2 Statement of the problem

Climate variability and change is one of the greatest environmental, social and economic challenges facing humanity today. It is a phenomenon that undermines the drive for sustainable development, particularly in Sub-Saharan Africa (Scholes & Biggs, 2004). Arid and Semi-Arid Lands (ASALs) are most vulnerable to climate variability and change (Kagunyu, *et al.*, 2016). Studies have not be conducted to collect data in the study area on the impacts of climate variability to water and pasture resources. In spite that studies have been conducted in Turbi Division regarding

traditional communities and adaptation strategies, no such studies relates them to climate variability.

As aforementioned the pastoral systems are highly dependent on intimate knowledge of their natural environment. IPCC (2007) projected that with or without climate change, some regions in Africa are likely to deplete their land-based water resources in the next decade which adds to the fear that climate change is here with us (GoK, 2010a; Arnell, *et al.,* 2014). Variations in rainfall and temperature as well as their effects on water and pasture resources have played a key role in determining changes in climate. If rainfall and temperature have varied significantly and the residents are aware of these climatic changes, this would translate in water and pasture availability, accessibility and affordability as well as influencing the utilization of these resources. The adaptation strategies to address the variations may not be available and communities are exposed to challenges associated with their implementation. This study therefore aims at identifying and documenting adaptation strategies attributable to the effects of climate variability in water and pasture scarcity among the pastoralists of Turbi division, Marsabit County.

1.3 Objectives of the study

1.3.1 General objective

The general objective of this study was to determine the effects of climate variability and climate change on water and pasture and the adaptation strategies adopted by the pastoralist communities in Turbi division, Marsabit County, Kenya.

1.3.2 Specific objectives

The specific objectives of the study are:

1. To find out the temperature and rainfall pattern in the last thirty (30) years and their impact on water and pasture.
2. To compare traditional and conventional strategies of coping with water stresses and pasture scarcity.
3. To identify the challenges faced by the communities in an attempt to cope with water stress and pasture scarcity.

1.4 Research questions

The research questions used in the study are:

1. How has temperature and rainfall been in the last 30 years and what are the effects of climate variability on water and pasture?
2. What are the traditional and conventional strategies of responding to water stresses and pasture scarcity?
3. Which challenges are faced by community members in an attempt to cope with water stress and pasture scarcity?

1.5 Hypotheses

H_o1. There is no significant variation of temperature and rainfall in Turbi Division for the last thirty years (1984 – 2014).

H_o2. There is no difference between traditional and conventional adaptation strategies in response to water stress and pasture scarcity.

$H_0$3. There is no relationship between climate variability to water and pasture availability in Turbi Division.

1.6 Significance of the study

The study identified problems of adapting to new challenges of water and pasture scarcity as well as suggesting better strategies for achievement of sustainable livelihoods and eradication of poverty. The findings will be useful to the community members and stakeholders involved in provision of these resources for improvement of quality of life. The findings will be used by government agencies, Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs) and other stakeholders to benefit local communities living in ASALs. The findings will also be used in implementation of National Climate Change Response Strategy (NCCRS), Kenya's Vision 2030 and development projects in the ASALs as a reference point for water resources development planners in seeking adaptation strategies relevant to nomadic pastoralists' lifestyle. In the long-term, the findings will enhance resilience to climate change, promote sustainable economic growth of the county and inform development priorities by governments.

1.7 Limitations of the study

The study assumed that the participants understood survey questions and that they have had enough experience and knowledge on the subject matter.

The study intended to administer a total of 400 questionnaires but due to inaccessibility and frequent mobility of pastoralists, a large number of the questionnaires were not administered. Due to lack of formal education among the pastoralists, it was impossible for the respondents to read and answer the questionnaires on their own hence research assistants were engaged. Insecurity and fear of the unknown in the study area influenced the smooth atmosphere in which the data was to be collected.

1.8 Conceptual framework

Climate change influences temperature and rainfall patterns. This phenomenon affects the basic pastoralist life supporting resources such as water and pasture (Lelenguyah, 2013). The result of such adverse climatic condition is devastating for both human and livestock since they directly rely on conditions of the prevailing weather under whose impacts they flourish or perish. Severe climatic conditions such as failure of seasonal rainfalls will result into mass loss of livestock and human suffering due to water and pasture scarcity. Addressing such vulnerability depends on the adaptive capacity of the local communities. In a bid to reduce severity of conditions such as drought and famine, pastoralist will adopt traditional and conventional adaptation strategies. Pastoralist's adaptive capacity will depend on people's access to climate information, their willingness to adopt, availability of technology and effectiveness of environmental laws and government policies. Proper and timely integration of adaptation strategies and systems that strengthen the capacity to adapt to climate change adversities will contribute to achievement of sustainable pastoralism as summarized in Figure 1.1.

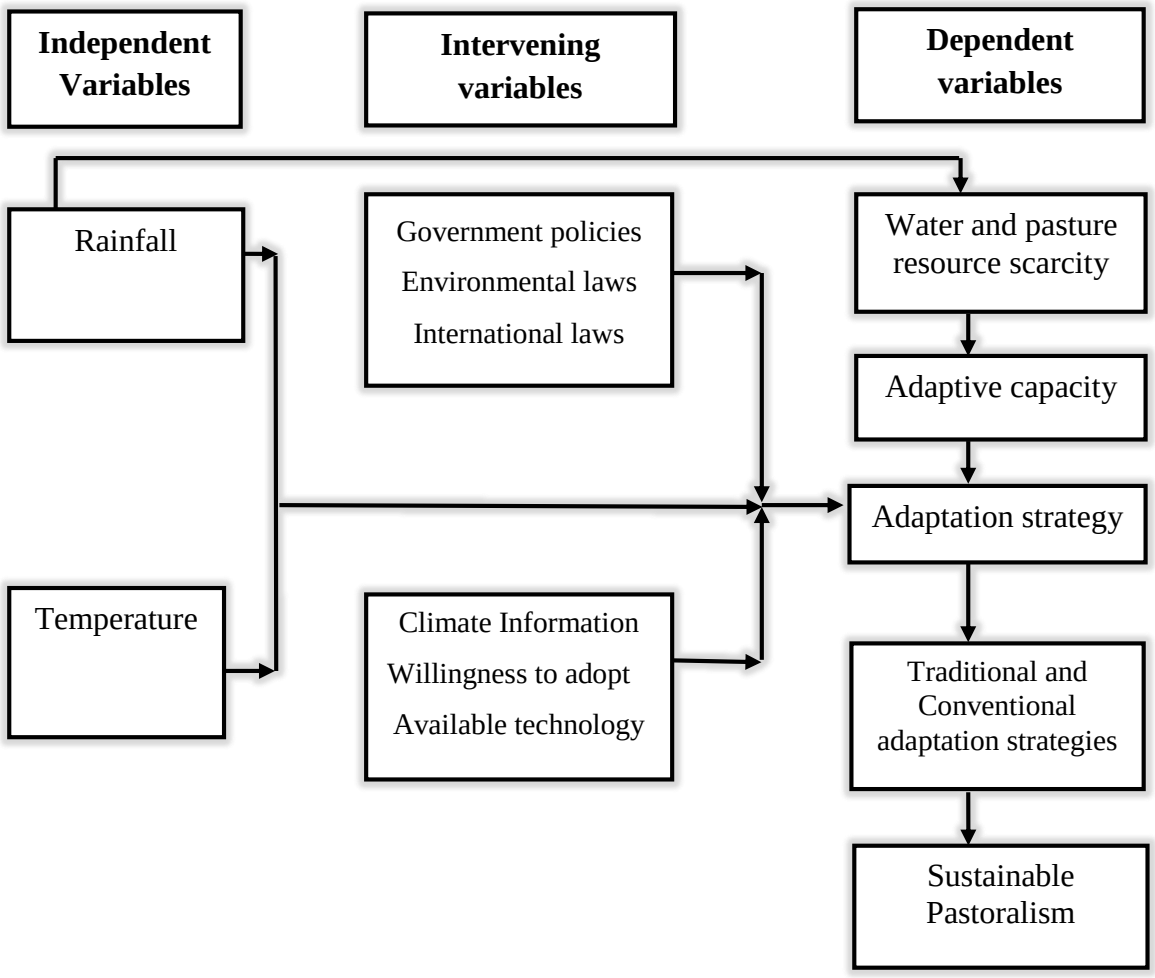

Figure 1.1: The conceptual framework

Source: Adopted and modified from Lelenguyah (2013)

1.9 Definition of terms

Climate Change – is the long-term variation in the distribution of weather patterns. It is measured using change in average weather conditions like rainfall and temperature. The study particularly focused on **vulnerability** which is the degree to which a community is susceptible to, or unable to cope with adverse effects of climate change.

Resource Scarcity

This is the inadequacy in resources that is either natural, climate induced or human induced (CDC, *et al*., 2009; Megersa, 2013). Resource scarcity has been seen as either relative or absolute (Temesgen, 2010). The terms abundant endowment and resource abundance were used to denote the opposite of resource scarcity (Adano, *et al*., 2012).

Water Scarcity – Is the reduced quantity and quality of water resources such that water demand is greater than the supply and has been defined as reduced availability, accessibility, affordability or willingness to pay and utilization as well as insufficient human capacity and/or financial resources to develop the water resources (Agwata, 2005; Helldorff & Lemuna, 2010; Shisanya, 2005; Tera, 2012).

Pasture Scarcity – This is reduction in availability of fodder or animal feed shortage that are essential for livestock feeding systems including cut and carry, tethering or free grazing systems including trees, shrubs, grasses and legume species that occur naturally or planted (Megersa, 2013; Orodho, 2006).

Sustainable Pastoralism – Livestock based livelihood strategy with a firm foundation and is economically viable, socially acceptable and environmentally reasonable.

Adaptation Strategies

These are coping mechanisms, adjustments and interventions that are adopted in order to manage losses or take advantage of opportunities posed by climate change (CDC, *et al.*, 2009).

i) **Traditional adaptation strategies*:*** These are locally based knowledge systems, indigenous knowledge based on informal approaches that are neither Governmental nor market-based instruments and localized events and practices and other social structures that are acknowledged by the people as their own authenticity and/or who's legitimacy is attributed to the people or their ancestors (Gebresenbet & Kefale, 2012; Helldorff & Lemuna, 2010; IPACC, 2012; Mude, *et al*., 2007; Pratt, 2002).

ii) **Conventional adaptation strategies*:* -** Water and pasture scarcity-related adaptation strategies of recent times, novel approaches, new '*Imported'* or emergent coping mechanisms associated with technology transfer and capacity building by stakeholders, introduced therefore as either governmental or market based instruments adopted to supplement local strategies synergistically and aimed at strengthening resilience of the communities (Brooks, 2006; Gebresenbet & Kefale, 2012; GROOTS KENYA, 2016; Hurst, *et al*., 2012).

1.10 Chapter Summary

This chapter discusses the background of the study focusing on the effects of climate change on water and pasture at global, regional and local scales. The chapter introduces the statement of the problem, study objectives, research questions and hypothesis. The section further highlights the significance of the study, limitations and how they were addressed. The chapter arrives at a conceptual framework showing the relationship between dependent variables (water, pasture and adaptation strategies) and independent variables (temperature and rainfall) for the achievement of sustainable pastoralism. It highlights that climate variation is a threat to the availability of water and pasture resources which are lifeline of pastoralist in the study area.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Climate change is a long-term shift in the climate of a specific location, region or planet. The shift is measured by change in features associated with average weather elements such as temperature, wind patterns and rainfall. Concerns about climate change are global and real and in Kenya, it has been described as unmistakable and its effects have been termed as undeniable (Arnell, *et al*., 2014; GoK, 2010a). As all countries get adapted to the challenges of their local climate, they are today sensitive to its variations. Third world countries, particularly Africa are threatened by the predicted effects of climate change because of their economic dependence on climate for development whose backbone is agricultural activities like crop farming and livestock keeping (Ngaira, 2008).

Studies on climate change have been done at global, regional and national level. Studies carried out by the Stockholm Environmental Institute SEI (2009) and submitted to the 15th Conference of Parties (COP 15) of the United Nations Framework Convention on Climate Change (UNFCCC) were aimed at estimating the potential impacts and economic costs of climate change in Kenya using aggregate models inter alia. Among the major findings, the country would suffer almost 3% loss of Gross Domestic Product (GDP) each year by 2030 including threats associated with sea level rise, infrastructure, water resources, ecosystem services and impacts on sectors like health, energy and agriculture. While the nation plans on a breakthrough 2030, the study further postulated major macro-economic costs and reductions in economic growth associated with extreme droughts and periodic floods (GoK, 2007). These are not the only works showing the reality of climate change at various scales; institutions such as IPCC, (2007); IPACC (2012) and National Environment Management Authority (NEMA, 2006) have extended analogous concerns while researches and scenarios such as Arnell (2003) and Arnell, *et al*., (2014) have linked climate change to water stress and changes in the terrestrial ecosystems. Recent literature is available on climate change, water and pasture scarcity, adaptation strategies and their associated challenges as discussed in this chapter.

2.2 Water and pasture resource scarcity

Climate change is strongly associated with increased water scarcity and stress. Foremost, Kenya is profiled as a water scarce country and the Intergovernmental Panel on Climate Change (IPCC) predicts that major effects of climate change on African water system would be through changes in the hydrological cycle, the balance of temperature and rainfall (IPCC, 2007). Water supplies from rivers, lakes and rainfall are characterized by their unequal natural geographical distribution and accessibility, and unsustainable water use (IPCC, 2008). In that sense, climate change has been blamed for water scarcity (Arnell N. , 2003; SEI, 2009). A research was done by Tera, (2012) to assess water resources utilization and management in Chahi sub-catchment, Kisoro district, Uganda and found that 98% of water scarcity was due to climate change. Despite Adano *et al.,* (2012) insisting that conflicts and water scarcity have no relationship, researchers show how water scarcity induced conflicts in Kenya and Tanzania especially when coupled to scarcity of other resources and social systems (Helldorff & Lemuna, 2010; Mtalo, 2005; Temesgen, 2010).

Water is one of the most important of all natural resources (Agwata, 2005). It is vital for all living organisms and major ecosystems as well as for human health, food and economic development (NEMA, 2006). Life on earth depends upon water availability and accessibility (Mugera, 2012). Climate change has affected global hydrological cycles with major impacts on regional water resources (IPCC, 2008). A change in the volume and distribution of water affects both ground and surface water supply for domestic and industrial uses, irrigation, hydropower generation, navigation, in-stream ecosystems and water-based recreation and these have been associated with both affordability in terms of water pricing and the utilization (Tera, 2012).

Water has been described as a finite and vulnerable resource and the population at risk of increased water scarcity in Africa is projected to be 75-250 million and 350-600 million people by 2020s and 2050s respectively (Arnell N. , 2003; Helldorff & Lemuna, 2010). Water scarcity affects both human and livestock, it has been blamed for increased poverty levels and is therefore a concern to Kenya's economy (GoK, 2007). The economy is characterized with climate dependent livelihoods including agriculture and pastoralism. Indeed, most of the country lies in the ASALs, supporting more than 30% of the total national population - usually pastoralist communities - and 70% of the

livestock production (GoK, 2010a). Water scarcity is therefore a threat to pastoralists who are in constant mobility for water and pasture (Mworia & Kinyamario, 2008).

Water scarcity is defined as a situation where water availability in a country or region is below $1000m^3$ per person per year (Tera, 2012). Water scarcity is a man-made disaster (Mude, *et al*., 2007; Mathenge, *et al*., 2014). It could also be a natural water scarcity that results from arid and Semi-Arid climate and droughts (Pereira, *et* al., 2002). More than three quarters of Kenya's total land surface area fall within the arid and semi-arid lands (GoK, 2007). In these regions, rainfall is lost through evaporation and uncontrolled runoffs. The main sources of water are boreholes and few perennial rivers which have low flows in the dry season (Ojany & Ogendo, 1988). The majority of the populations of these areas are pastoralists. Similarly, climate change has also been attributed with degradation on pastoral rangelands in these regions (Gebresenbet & Kefale, 2012).

While Temesgen (2010) and Ember *et al.*, (2012) uses droughts and seasons of low rainfall as indicators of resource scarcity, this study particularly focused on the scarcity of water and scarcity of pasture. Water scarcity could be caused by uneven distribution, inadequate and unreliable rainfall, environmental degradation, and poor community water management practices, and increased human and animal population (Agwata, 2005, Marsabit, County Government of, 2013; Tera, 2012).

Pasture and water resources have been key players in pastoralists' way of life and the varying climate has always been met with flexibility. Areas inhabited by pastoralists are of low and highly variable rainfall conditions steep terrains and extreme temperatures (Flynn, 2006; County Government of Marsabit, 2013; Scott-Villiers, et al., 2015). Pastoralism has been defined as economically viable (Moritz, 2012; Brooks, 2006). This is through a set of complex practices outlined by (Gebresenbet & Kefale, 2012). The other most important is and indigenous knowledge (Dabasso, *et al*., 2012; Kagunyu, *et al*., 2016). It is further described as socially acceptable and environmentally sustainable (Neely, *et al*., 2009). This is primarily because of employing successful adaptation mechanisms to uphold ecological balance between people and nature in environments that are dynamic, vulnerable and unpredictable (Helldorff & Lemuna, 2010; Ruto, *et al*., 2009). The figure that follows shows how

sustainable pastoralism maintains an equilibrium among pastures, livestock and people (Koocheki & Gliessman, 2005).

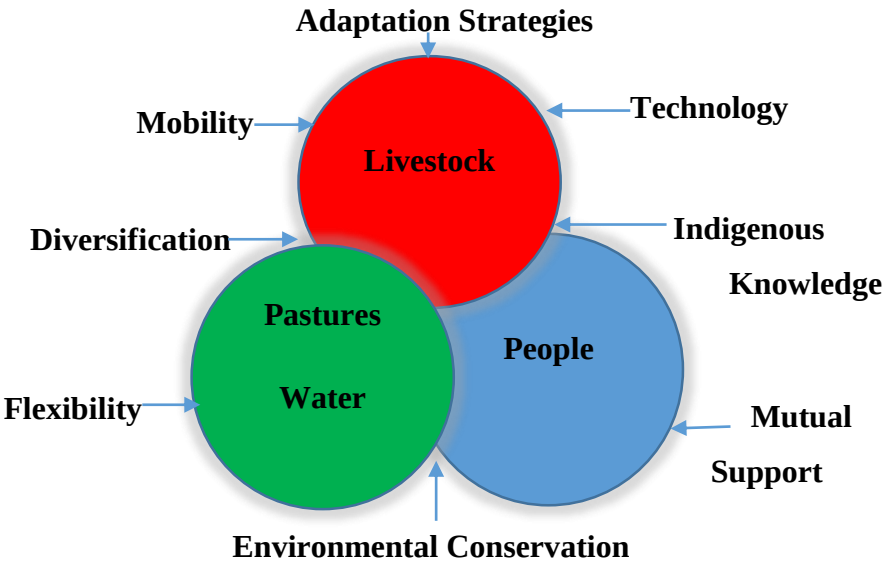

Figure 2.1: Pastoralism: sustainable natural resource management

Source: Adopted and modified from Koocheki & Gliessman (2005)

In the Figure 2.1, pastoral systems are seen to be dependent upon the wellbeing of livestock, intimate knowledge of the surrounding natural environments, ecosystems, political and economic environments, climates and availability of resources (Dabasso, et al., 2012; Megersa, 2013). Pastoralists across the GHA and specifically in Marsabit County have demonstrated their resilience to the naturally changing climate for centuries by thriving in ASALs where water and pasture is scarce (Adano, *et al*., 2012; Boru & Koske, 2014). However, the resilience and resourcefulness that have enabled them to thrive for those years are coming under significant stress today. According to Doti (2010), the impact of anthropogenic induced climate change such as high temperatures and erratic rainfall, are threatening their adaptability making pastoralism highly vulnerable (Megersa, 2013; Helldorff & Lemuna, 2010).

Besides human population growth, climate change caused mainly by the use of fossil fuels and deforestation has also affected the demand, supply and quality of surface water resources globally causing water scarcity which is a limiting factor in both social and economic development. In the developing countries, the problem of water is more serious in the rural areas where the majority of the people live. Moreover, most of the

countries are in the ASALs where rainfall is highly unreliable and persistent drought is a common phenomenon and the rangelands are continuously receding (GoK, 2010a).

Semi-arid and arid areas are particularly exposed to the impact of climate change on fresh water for both human and livestock consumption. In the wake of climate change any of these areas will suffer a decrease in water resources as population increases and ground water recharge is set to decrease considerably which is likely to hamper efforts to offset the scarcity. Marsabit County has suffered from acute and chronic water shortage and the study area, lying largely in arid land may be the worst hit (GoK, 2008). Today, the changes in temperature, rainfall, and sea level rise have left varying consequences on the availability of fresh water in the region. Irrespective of significant changes in the rainfall amount, there are additional stress on water resources especially where temperature rise has led to great water loss through evaporation (Waititu, 2009). Recent droughts have had devastating impacts on water and pasture in Northern Kenya (CDC, et al., 2009).

Pastoralists have lived in the area for generations and over time have developed highly efficient methods of adapting to their environment. In Kenya pastoralist production has been one of the most efficient livelihoods (Moritz, 2012; Doti, 2010). Kenya has been profiled as a water scarce county by GoK (2010a) but the fact that statistics show that population is growing and that the economy is set to grow in the near future is enough to deduce that this 'water scarce country' stands between inadequacy and abundance (KNBS, SID, 2013). In the past for instance, pastoralists relied on natural water and pasture which were routinely replenished by seasonal rainfalls and their way of life has been described as the most viable and productive (Aziz & Kisiangani, 2011; Megersa, 2013). These allowed them to practice dynamic, flexible and independent movement within and outside their boundaries as they continued to flourish (NEMA, 2006).

Recently, there are variations of rainfall patterns between and within seasons coupled with increased temperature and recurrent droughts which have virtually rendered all the pools dry and continuously diminished pasture sources (Temesgen, 2010). The practice of moving away from permanent water sources during the rainy seasons has come to be a thing of the past and the land has been seriously degraded, particularly those neighboring permanent water sources (NEMA, 2006). Distances between watering

points and pastureland have of late became extremely vast even for hardy animals like camels to cope with (Kagunyu & Wanjohi, 2014). The focus of most of the work done to date on water and pasture scarcity has been carried out often at the scale of globe, regional and country. More detailed information is needed on adaptation strategies adopted by the communities so that timely and effective adaptation policies can be appropriately targeted.

2.3 Adaptation strategies to water and pasture scarcity

Areas and regions where water scarcity has always been high have given birth to civilizations and/or coping strategies that have been able to address the water scarcity (Gebresenbet & Kefale, 2012). The challenge, though is finding such a mechanism in societies living in water stressed areas which impinge on the cultural, social and environmental facets of water resources (Pereira, *et al*., 2002).

All over the world, many adaptation strategies have been innovated. These include both modern and traditional and modifications of the latter. For instance, associations among pastoralists were formed in Nigeria in early 1980s, whereby they managed the water collection system on clustered household basis (Pacey & Andrian, 1986). The strategy behind this management of water on a cooperative basis was to minimize misuse and overuse of water resources so as to conserve enough for the dry season. In other livestock areas, excavated runoff harvesting techniques have been used to conserve rainwater. This includes the use of cisterns, small dams, rock catchments, sub surface dams and weirs. It's been observed that pastoralists utilize natural rain filled pools immediately after the rainy season while water in the artificial pools is conserved for later use (Pacey & Andrian, 1986).

A study carried out in Southern Ethiopia mapped a range of traditional adaptation strategies including migration and diversification inter alia which proves that pastoralists have had coping mechanisms long enough (Gebresenbet & Kefale, 2012). Changing climate adaptation strategies among the Borana in Ethiopia was studied by (Hurst, *et al*., 2012) while (Megersa, 2013) focusing on cattle herd vulnerability and food insecurity in relation to climate change with special focus on livestock diversification as an adaptive strategy. In Sudan, where the population is dependent on livestock, studies show that the pastoralists adapt by digging 'Hafirs' so that livestock

are watered via wells using suitable drinking troughs (Cloudsley, 1978). The inflow of water is usually via a silt trap. During drought the amount of water given to livestock is controlled which was noted by Timberlake (1988) to also protect the area around the wells from degradation by many animals as compared to the communal wells.

Researches in the Horn of Africa include Ingrid & Sugulle (2009), in the Northern Kenya and North Eastern region focusing on pastoral communities and the adaptation strategies employed to address water and pasture scarcity. These include a study on conflicts and climate change that focused mostly on conservancies in Northern Kenya (CDC, *et al*., 2009). Studies on traditional knowledge were done by Dabasso, *et al*., (2012); while a special attention on methods of weather forecasting was adapted by Kagunyu, *et al*., (2016) and Pratt, (2002). Doti (2010) documented climate change in Northern Kenya, though, not with specificity to the study area which happens to be the case with the studies carried out by Watete, *et al*., (2016) and; on ASALs by Centre for Training and Integrated Research for ASAL Development (CETRAD). These studies fail to address the local status of climate variability with emphasis on water and pasture scarcity in the study area.

A survey by ACTED (2011) found that, many communities in the affected arid and semi-arid lands have not had enough time to re-build their livelihood assets and have already exhausted coping mechanisms during the 2009 drought. This situation was also observed by Gebresenbet & Kefale (2012) who also noted that local communities modified traditional adaptation strategies to fit current socioeconomic realities. Coping with water and pasture scarcity seems to be changing. Water scarcity for instance, provides a basis for innovations in examining the value (Helldorff & Lemuna, 2010); and encourages different thinking in assessment of the social, environmental and economic values of water to establish appropriate priorities for water allocation and use (Agwata, 2005). Further, researches show that measures to address water scarcity cannot be successful unless there are measures to use the available water sustainably (Hurst, *et al*., 2012). This arouses curiosities and questions regarding the study area and the communities residing therein including whether climate has varied significantly and that the adaptation strategies have subsequently changed.

2.4 Challenges in adaptation strategies

Fulani pastoralist in Niger were the target of a study by the International Livestock Research Institute (ILRI) and one of their major adaptation strategy was destocking (Aziz & Kisiangani, 2011). Concerns arose as uncertainties associated with destocking make herd reconstitution very difficult after a drought. While other traditional adaptation mechanisms have also been faced with many challenges others have been termed as better suited, or being modified to fit current realities, they are still constrained by multiple factors and may be no longer sufficient in the verge of changing climates (Gebresenbet & Kefale, 2012; Megersa, 2013; Mworia & Kinyamario, 2008). These strategies are slowly succumbing to climate change which is now feared to be humanity's greatest challenge affecting both current and future generations even when they were meant to address it (Munga, 2012). Evidently, these strategies ought to be supplemented to fit the dynamic nature of the current realities.

Further, newer strategies such as provision of water have contributed in diverse ways to the livelihoods of many people in the arid and semi-arid lands (Kangalawe & Liwenga, 2005). To address water scarcity, increasing the cost of water has been named as coping mechanism by Mtalo (2005) adding in the issue of water affordability to the poor pastoralist. Even with water availability, accessibility and affordability, however, one of the major constraints to the wise use of water resources which has been impugned to the lack of knowledge by planners and natural resource managers on the benefits that they provide and techniques that can be utilized in a sustainable manner (Ngana, *et al*., 2004). Availability and accessibility of water by people and livestock will potentially lead to overstocking which in turn results to degradation of pasturelands (Hurst, *et al*., 2012). On the other hand, water scarcity will lead to a similar degradation of the pasturelands. This is probably why water shortages and environmental degradation have been named as the two of the main challenges facing humanity in the 21st century (Poudel, 2003). Many researchers such as Pratt (2002) and Robinson (2009) express concerns regarding the viability of pastoralism is in present times.

As a result of climate change, pastoralists' way of life is undergoing great transformation and the trend is moving towards higher vulnerability, loss of solidarity mechanisms for coping with drought and destitution as noted by Pratt (2002). Due to abandoning of pastoral ways of life, traditional coping mechanisms are being

continuously eroded (Ingrid & Sugulle, 2009; Temesgen, 2010). Climate change affects the function and operation of existing water infrastructure, including structural floods defenses and drainage systems (IPCC, 2008). Adverse effects of climate change on freshwater systems aggravate the impacts of other stresses, such as population growth, changing economic activity, and land use change (Tera, 2012). Recent studies conducted both regionally and locally have dwelt much on identifying the impacts of climate change and variability on the local structures and related responses (Boru & Koske, 2014; Dabasso, *et al*., 2012). Others have focused on the consequences of such changes but none has given specific attention to climate variability in respect to challenges facing adaptation strategies to water and pasture scarcity in the study area (Diba, 2015; Doti, 2010; Ember, *et al*., 2012).

2.5 Research gaps in the study area

Local communities are highly vulnerable to climatic variability and changes in seasonal patterns. These negative impacts are being compounded by multiple factors which includes increased demand for food and population density, increased widespread poverty, human and livestock disease as well as water and pasture scarcity (IPCC, 2007; IPCC, 2008; NEMA, 2006). These effects have a trickling action on the economic and social spheres affecting the availability, accessibility and affordability of water and pasture resources. These also affect livestock production, energy use and demand, water and pasture utilization as well as the entirety of biodiversity within the ecosystem that (Adano, *et al.*, 2012; Arnell N. , 2003; Aziz & Kisiangani, 2011; Brooks, 2006; Doti, 2010; Ellis, 2000; Hany & Nelson, 2009; Mude, *et al.*, 2007; Temesgen, 2010).

The geographical location of Kenyan pastoralist makes them highly impacted on by climate change, presenting varying vulnerabilities. In this connection, not all groups within the society have the same adaptive capacity (GoK, 2010a; Pereira, *et al*., 2002). Affordability of pasture and water resources as well as financial and social capacity to secure alternative livelihoods and the ability to manage these resources in scarcity is likely to reduce exposure to risk and therefore increases resilience to climate change (Aziz & Kisiangani, 2011; Doti, 2010; Mutimba, *et al*., 2010).

In regions where permanent rivers and water catchments are available, studies on water management have been carried out by among others Agwata, (2005); Mathenge, *et al.*,

(2014) and Kangalawe & Liwenga, (2005). Such attention has not been invested in regions where water is under huge stress and ought to be managed more. Water stress aggravated by climate change is being faced by the local people in Northern part of Kenya. Consequently, there is increased migration in search of water. More boreholes, water pans and shallow wells have been dug and constructed (Doti, 2010). Climate change and variability has imposed additional pressure on water and pasture availability and accessibility which have not been studied in Turbi Division. As a result, the cost of water and pasture is varying and raising questions of affordability as well as management of these resources for efficient utilization.

A meteorological study done by Ouma (2015) to assess the impacts of climate variability on livestock in four counties of Northern Kenya, successfully used Standardized Precipitation Indices (SPI) inter alia to map drought severity in the region. The intensity and frequency of droughts have changed inhibiting the ability of the local communities to predict and plan for disaster risks (Boru & Koske, 2014). This implicates on their livelihood and on the ecological systems and therefore posing a challenge of food security, and access to water and pastureland (Megersa, 2013; Mutimba, *et al*., 2010). While pastoralists in Marsabit County live in drought prone areas, droughts could be blamed for the migration of peoples, cultural and communal parting and dislodgment (County Government of Marsabit, 2013). Traditional knowledge and in-depth understanding of the land has been used for centuries as the foundation for the local people's capacity to adapt to changes in such environments (Dabasso, *et al*., 2012; Kagunyu, *et al*., 2016; Pratt, 2002).

The challenges facing quite a number of adaptation strategies have been overlooked while others have completely been avoided. The forecasting of weather, early warning systems and understanding of pasturelands by the local communities have been greatly distorted. For instance, a study conducted in areas adjacent to Turbi Division by Dabasso *et al.,* (2012) revealed that weather predictions were based on atmospheric patterns, local plants and animal species. These were noted to be on the verge of annihilation and therefore alienating the people from the knowledge of their land (Dabasso, *et al*., 2012). Similarly, the familiar homelands and natural phenomena are disrupted and knowledge that has helped the local communities adapt to climate variability is facing great danger.

The once known mobile pastoralists are doomed to sedentary lives characterized by what we only have a faint idea of, unless there are supplementary adaptation strategies. What these adaptation strategies are and the challenges faced by communities in their adoption in the study area remain obscure.

Other researches carried out in the study area include Diba (2015), who sought to profile the inter-ethnic conflicts between the Gabra and Dassanetch communities from 1960 to 2005 that were found to be as a result of a clashes in the sharing of the scarce natural resources. These resources included water and pasture. Similarly, Robinson (2009) who while studying the capacity of Gabra pastoralists in the study area and beyond found that their traditional livelihood strategies and social-ecological systems were resilient to shocks and stresses in water and pasture scarcity. Studies have not been carried out on the effects of climate variability on water and pasture scarcity in the study area.

2.6 Chapter Summary and conclusion

In conclusion this chapter reviews recent literature at global, regional and local levels. Climate variability is still ongoing. For the reason of such limited knowledge, differing guidance by researchers coupled with the context specific nature of climate variability, challenges of scale and complexity, climate change adaptation at local level has been a vacuum of knowledge inviting to be refurbished. Literature is available of climate variability and change that highlights ongoing and anticipated negative effects. Water and pasture scarcity in the ASALs have been identified as impacts of climate variability and change. Studies have revealed that climate change threatens the sustainability of pastoral life. Although these findings are based on data gathered from different areas, the effects of climate variability differ significantly from one region to another depending on livelihood resources in the area. Moreover, climate variability impacts depends on physical location and topography of different geographical areas. Since such research has not been conducted in the study area, it is important to gather this vital information. Water and pasture scarcity and adaptation strategies in various regions are being continuously unveiled as adequate site specific recommendations are given. Therefore, there is need to collect data on traditional and conventional adaptation strategies to climate change.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology. It starts with description of the study area including the location, climate and economic activities. The study design, and sampling procedures are also described, outlining the sources of data and methods of data collection. In addition, various statistical procedures used in data analysis and hypothesis testing have been explained.

3.2 The study area

3.2.1 Location

The study was carried out in the arid rangelands in Turbi Division (Figure 3.1) of Marsabit County, Kenya. The area lies between latitudes $01^0\ 85^0$ North and $03^0\ 27^0$ North of the Equator and longitudes $39^0\ 03^0$ East and $39^0\ 90^0$ East of the Prime Meridian. The division is located in the eastern part of the Marsabit North District. It borders Wajir District to the East, Isiolo and Marsabit Central Districts to the South, Maikona Division to the West and Moyale District and Ethiopia to the North. The total area of the division is 10,820.8km^2 (County Government of Marsabit, 2013). Administratively, the Turbi Division is divided into four locations namely; Shurr, Bubisa, Burgabo and Turbi as shown in the Table 3.1.

Table 3.1: Administrative locations in Turbi Division

Administrative Location	**No of Sub-locations**
Shurr	2
Bubisa	2
Burgabo	2
Turbi	2

(Source: Sub-county office)

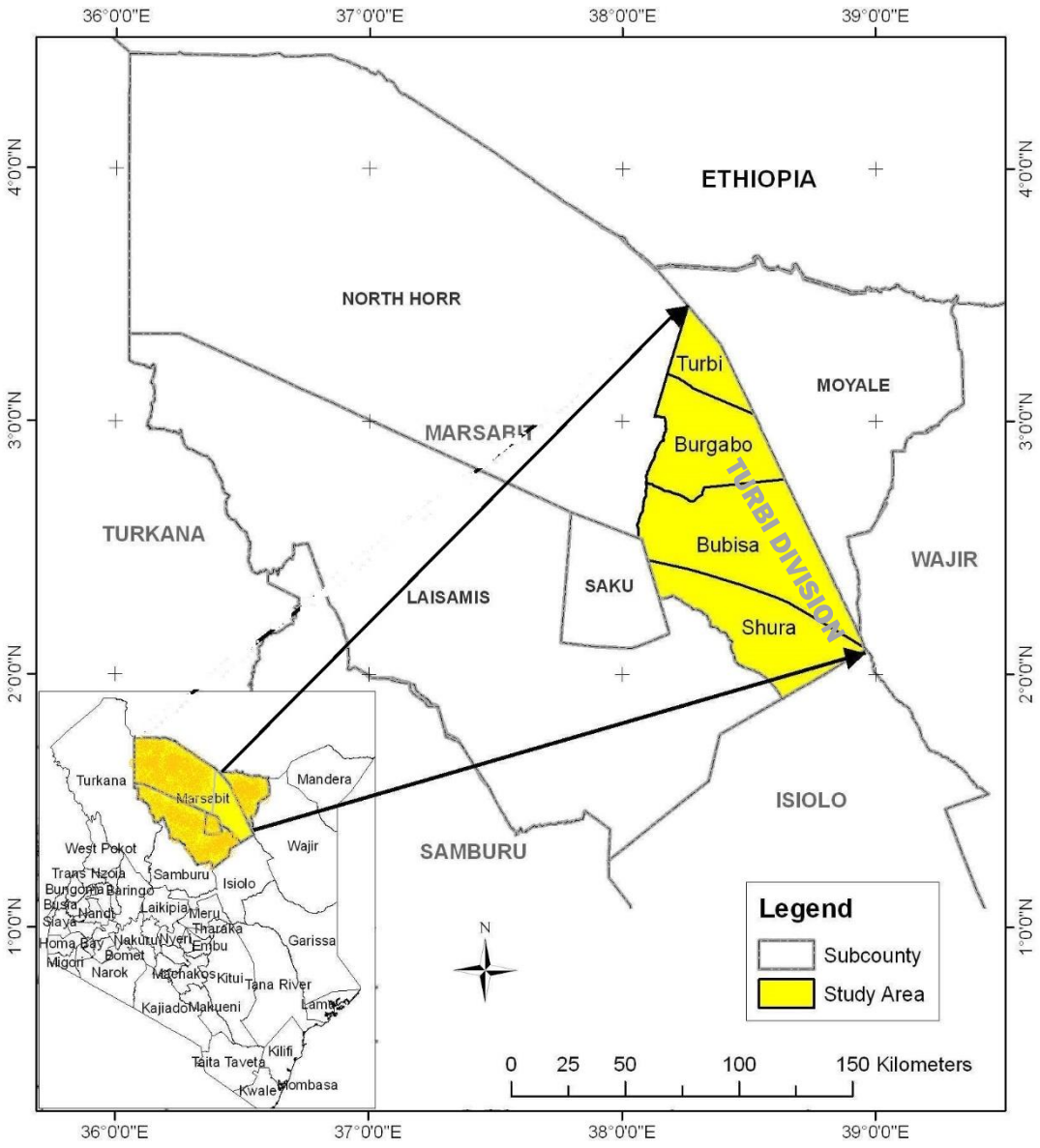

Figure 3.1: Map of Kenya showing Marsabit County and Turbi Division

Source: KU GIS Laboratory

3.2.2 Climate and Relief

The division has a harsh climatic condition of extreme temperatures ranging between low of 18^0 to high of 38^0 with extremely hot days and very cold nights. The division is characterized with low erratic rainfall averaging between 250-400mm a year and prolonged sporadic droughts. Topographically the division is a flat stony plain that begins from the foot of Hurri Hills 1685m in the west and stretches between Marsabit Mountain in the south and Ethiopia's Mega escarpment in the north (GoK, 2008). The

division is naturally water and pasture deficit zone with no lakes, rivers, shallow wells except seasonal natural water pools and swamps (GoK, 2008).

3.2.3 Population size and economic activities

Turbi Division is a sparsely populated arid region. The estimated population size is 10295 people out of which 5291 are working class (KNBS, SID, 2013). The main economic activity is nomadic pastoralism. The area is occupied by Gabra nomadic pastoralists with 2551 households of relatively high mobility. Due to its harsh aridity and unfavorable environmental conditions nomadic pastoralists are used to roaming with their livestock in search of pasture and water resources. The majority of the population in the division are youth below age 24 (67.8%), mostly school attending age bracket (County Government of Marsabit, 2013).

3.3 Research design

The research design was a survey. The survey adopted the use of qualitative and quantitative approaches. Empirical tools such as questionnaires, observations and interviews were used to collect data from different sources. The survey respondents were identified using stratified systematic sampling method. The four locations in the Division were used as strata. Finally, qualitative approach allows for description of a given phenomenon while quantitative approach allowed the description of the relationships between variables (Mugenda & Mugenda, 2003).

3.4 Data Collection, sources and sampling procedure

3.4.1 Sampling size

The study area has 2551 households which were considered as the study population. The sample was calculated using a formula by Yamane, (1967) who provides a simplified formula to calculate sample sizes (Yamane, 1967).

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

Where n is the sample size, N is the household population size, and e is the level of precision which was 95% confidence limit.

$$n = \frac{2551}{1 + 2551(0.05)^2} = 400$$

3.4.2 Household questionnaires

The main tool used in collection of data from the respondent was the use of questionnaires. The questionnaires contained both open-ended and close-ended questions. Due to various limitations the study managed to collect data from 203 households out of the anticipated 400. The households reached were not uniformly distributed to locations. Starting from the chief's household, the questionnaires were administered to every twelfth household using a systematic sampling method. Since all respondents could not read and write, research assistants who were conversant with the local language were engaged.

3.4.3 Key informants and FGDs

Purposive sampling was used for selection of nine key informants and one focused group discussions (FGDs) for every stratum. Interviews were conducted with key informants selected from government agencies based on their technical expertise, personnel from local NGOs and leaders of Water Users Associations (WUAs). FGD's members were mobilized with assistance of area chiefs. These members comprised of opinion leaders and representatives from local community organizations such as women groups and community WUAs.

3.4.4 Weather and climate data

Rainfall and temperature data for a period of thirty years (1984 - 2014) was obtained from Kenya Meteorological department (KMD) in September 2016 (see Appendices 4-6). This data included monthly precipitation (in millimeters), minimum and maximum monthly temperatures (in degrees Celsius).

3.5 Methods of data analysis

3.5.1 Rainfall and temperature variability analysis

Climatic data was used as the independent variables. The parameters used to measure climate variability are rainfall and temperature. Rainfall and temperature data is statistically independent. Inter-annual variability in rainfall and temperature from the period 1984 to 2014 was calculated using standardized deviates (SDt) (Megersa, 2013).

$$SDt = \frac{x - \ddot{x}}{s} \qquad \text{Equation 2}$$

In equation 2, x is the annual mean, while ẍ and s are the long-term mean and standard deviation, respectively. This analysis test the hypothesis (H_{o1}: μ = M) that the annual and temperature mean (μ) is equal to the long-term mean (M). This analysis describes how widely rainfall or temperature across years are dispersed from the long-term average. Linear Regression Analysis was used to determine the significance of the variations and presented as graph. For further comparisons, Pearson's correlation coefficient (R) was used to calculate the inter-annual association between precipitation and temperature at 95% confidence limit. Feedback from the respondents on climate variability were compared with the results of the analysis to determine their consistency.

3.5.2 Household data analysis

The household's responses on water and pasture scarcity and adaptation strategies were used as the dependent variables. The parameters used for water availability includes the immediate and alternative sources of water and distances from water sources. To measure accessibility, distance to water sources and the frequency of watering days were analyzed. The frequency of watering days was contrasted between the present and past (fifteen years ago). The cost of water was contrasted for the present and past fifteen years to measure disparities in affordability. Utilization was analyzed in terms of management of water and pasture both when plenty and scarce. On climate change, the perceptions of climate knowledge and indicators of change were analyzed. The diversity of adaptation strategies used were also measured. The role of stakeholders and the variety of policy frameworks identified by the respondents were used as the intervening variables.

Data obtained from the households using questionnaires was analyzed using statistical package for social scientists (SPSS). Descriptive statistics were used to organized and summarize data into frequencies, percentages and averages. Logarithmic transformation was done on people's responses to reduces skewedness. Similar responses were added up to form a cluster value. The output was presented in form of tables, graphs and pie-charts. In order to get the clear picture of preference and popularity, the respondent's perceptions were normalised. A rank normalisation was calculated to convert ranks into standardized values [0, 1] using the following formula (Megersa, 2013).

$$Normalised\ rank = 1 - \left(\frac{(rank - rank_{min})}{(rank_{max} - rank_{min})}\right) \quad \text{Equation 3}$$

Chi-square test (X^2) test for heterogeneity was used to test the relationship between climate variability to water and pasture availability using cross-tabulated variables on people's response. One tailed t-test was conducted to test significance difference of adaptation strategies from the hypothetical mean ($\mu=0$). One tailed parametric t-test was used to establish the difference between adaptation strategies categorized as traditional and conventional ($p = 0.05$).

3.5.3 Qualitative method

Qualitative data collected from FGDs and key informant interviews was verified to ensure consistency and quality. Quotes and narratives were used to explain trends and reasons identified by respondents.

3.6 Chapter Summary

This chapter describes the location, topography, climate, population and economic activities in the study area. Further, sources and instruments of data collection have been discussed which include questionnaires for household surveys, FGDs and key informants. The research design, sample sizes and specific sampling procedures were also discussed. Data analysis instruments such at t-test, chi-square and standardized deviates were outlined. Procedure for testing for correlation between variables including Pearson's correlation coefficient and linear regression were also discussed.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and findings of the study. The findings are presented using graphs, tables and pie charts.

4.2 Demographic data

The study was conducted to establish the effects of climate variability on water and pasture availability in Turbi Division, Marsabit County, Kenya. The study targeted 4 locations of Turbi division; Bubisa, Turbi, Burgabo and Shurr.

Table 4.1: Summary of demographic information of households

Variable	Description	Bubisa	Burgabo	Shurr	Turbi	Total	Percentage
Gender	Female	23	4	12	49	88	43.3%
	Male	43	4	23	45	115	56.7%
	Subtotal	66	8	35	94	203	100.0%
Level of Education	Adult Education	4	1	2	5	12	5.9%
	None Attended	20	5	25	40	90	44.3%
	Primary	5		2	13	20	9.9%
	Secondary	15	1	5	26	47	23.2%
	Tertiary	22	1	1	10	34	16.7%
	Subtotal	66	8	35	94	203	100.0%
Length of Stay (Years)	0 - 5	14	4	23	15	56	27.6%
	6 - 10	16	2	12	26	56	27.6%
	11 - 15	13			26	39	19.2%
	16 – 20 +	23	2		27	52	25.6%
	Subtotal	66	8	35	94	203	100.0%
Occupation	Business Person	4		8	22	34	16.7%
	Crop Farmer				2	2	1.0%
	Formal Employment	16	1	1	9	27	13.3%
	Livestock Herder	42	6	24	46	118	58.1%
	Livestock Trader	2	1	1	13	17	8.4%
	Others	2		1	1	5	2.5%
	Subtotal	66	8	35	93	203	100.0%

In Table 4.1, the demographic data of the sampled population has been indicated. The background characteristics described in this section are gender, age, location of

residence, educational level, occupation and period of stay in the area by the households. The study revealed that 94 (53%), (66) 32.5%, 35 (17.2%) and 8 (3.9%) of the households come from Turbi, Bubisa, Shurr and Burgabo Locations respectively. Both male (57%) and female (43%) were sampled. The study further revealed that, the residents majority of whom are pastoralist livestock herders (58%) have lived in the study area for a varying period of time including less than 5 years (27.6%), 10 years (27.6%), 15 years (19.2%) and 20 years or more (26.6%).

4.3 Water and pasture availability

4.3.1 Households' water sources

Table 4.2: Primary and secondary water sources by location.

Source		Bubisa	Burgabo	Shurr	Turbi	Total	Percentage
Immediate Water Source	Borehole	63	5	30	29	127	62.6%
	Dam	1	0	1	33	35	17.2%
	Seasonal Dam/Pan	0	0	0	1	1	0.5%
	Shallow Wells	0	1	0	23	24	11.8%
	Under roof Tank	2	1	4	4	11	5.4%
	Underground Tank	0	1	0	4	5	2.5%
	Subtotal	66	8	35	94	203	100.0%
Alternative Water Source	Borehole	1	3	8	21	33	16.3%
	Dam	11	0	3	14	28	13.8%
	Natural Swamps/Pools	1	0	0	0	1	0.5%
	Rock Catchments	1	0	0	29	30	14.8%
	Seasonal Dam/Pan	5	0	1	1	7	3.4%
	Shallow Wells	1	0	5	4	10	4.9%
	Under roof Tank	4	1	7	7	19	9.4%
	Underground Tank	1	0	1	10	12	5.9%
	Water Catchment	0	0	0	1	1	0.5%
	No alternative source	41	4	10	7	62	30.5%
	Subtotal	66	8	35	94	203	100.0%

Table 4.2 shows immediate and alternative sources of water used by households. Boreholes were found to be more common water sources in Bubisa and Shurr with 95.5% and 85.7% respectively. The study found that the number of residents who have

access to a borehole are 127 (62.6%) and those who access a dam are 35 (17.2%) where (n=203). Other results for seasonal dam or earth pan, shallow wells, underroof tank and underground tank were 1 (0.5%), 24 (11.8%) 11 (5.4%) and 5 (2.5%) respectively. However, it was notable that 30.5% of the residents depended on only one source of water. For instance in Bubisa and Burgabo, (62.1%) and (50.0%) respectively depended on boreholes without an alternative source of water. On the other hand, rock catchments were common in Turbi where 30.9% (94) of the households used them as alternative water sources while the major water sources were ranked as dam, borehole and shallow wells with 35.1%, 30.9% and 24.5% respectively.

4.3.2 Distance from a permanent water source

The distances from the nearest permanent water sources to all households (n=203) as presented in a scatter graph as shown in Figure 4.1 shows that the majority of households are within a range of 10 kilometres away from a permanent water source. The average distance from a permanent water source is 8.09km with a standard deviation of 9.1124 across the data (n=203). The farthest distance to water source was 60km (Figure 4.1).

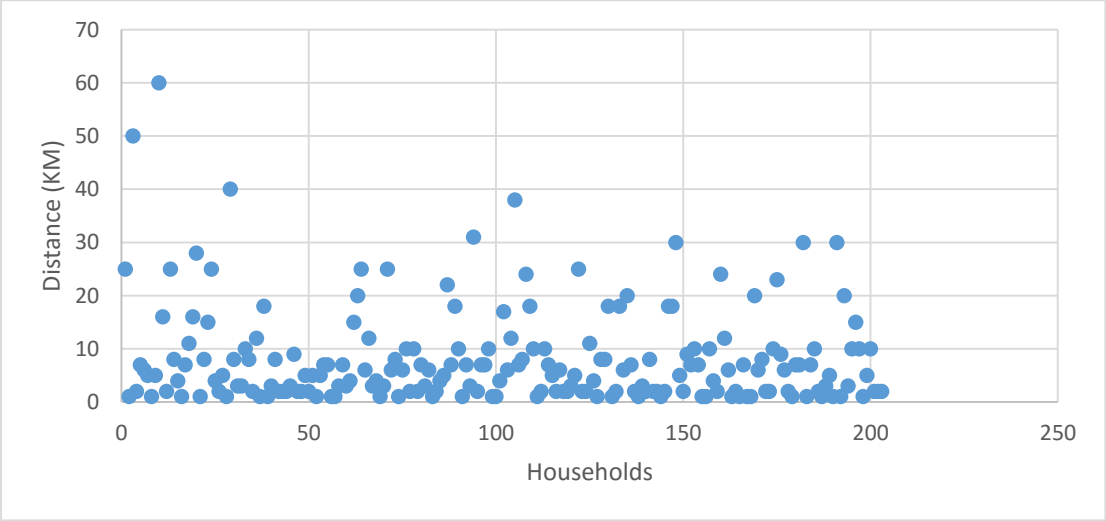

Figure 4.1: Distance from a permanent water source

4.3.3 Changes in availability of water and pasture resources

The study found that 76% of the respondent (n=203) had witnessed an increase in availability of water resources. The respondents also noted that increase in water and pasture resource availability was as a result of drilling more boreholes, storing water

and fodder, placing underground tanks and increased pasture management. This was followed by an increase in livestock population resulting from high rate of reproduction and immigration. This leads to overstocking, overgrazing and receding of rangelands.

In the Table 4.3, a large proportion (174) witnessed a decrease in resource availability while the rest (29) experienced an increase in resources available for their use. Chi square test showed that climate change had a significant impact on water and pasture availability ($X^2 = 3.5629$, df = 10, p-value = 0.9649). The reasons attributed to decline of water resources includes the tremendous increase in both human and livestock population without increase in water resources and migration of other pastoralists into the area. Some respondents noted change in water and pasture availability but did not give reasons. However, of those who explained, 45% reported resource reduction due to overstocking and overgrazing while 11.9%, 2% and 17.8% observed that prolonged droughts, high temperature intensity and unreliable rainfall respectively led to poor pasture regeneration. Prolonged droughts was responsible for the dried out surface reservoirs including dams, shallow wells, underground tanks and the reduced water output from boreholes.

Table 4.3: Change in water and pasture resource availability

Change Reasons	**Increase**	**Decrease**	**Cluster**	**Proportion**	**Rank**
Null	6	46	(1.243)	(0.227)	0.900
Drilling boreholes increased water accessibility	9	3	0.606	0.111	0.600
High temperature intensity	0	3	0.004	0.001	0.100
Migration of other pastoralists into our area	1	7	0.430	0.079	0.500
More underground tanks have been placed	4	2	0.305	0.056	0.400
Overstocking and overgrazing	2	66	1.359	0.249	1.000
Prolonged droughts	2	16	0.782	0.143	0.700
Storage of water and fodder available	0	1	(-0.473)	-0.087	0.000
There is improved pasture management	4	0	0.129	0.024	0.300
There is severe environmental degradation	0	4	0.129	0.024	0.300
Unreliable rains and poor pasture regeneration	1	26	0.958	0.175	0.800

4.4 Water and pasture accessibility

4.4.1 Trends in water accessibility

The study found that 74% of the households (n=203) had observed changes in accessibility of water for both humans and animals. Further, of those who witnessed reduced distance in water availability, (80%) had also witnessed changed in accessibility to water resources.

4.4.2 The number of days in accessing water for people and livestock

Changes in the number of days in acquiring water for both people and livestock (watering period) were analysed (Table 4.4).

Table 4.4: Summary for changes in days of water acquisition

Frequency (days)	**15 years ago**	**Present (2016)**	**Difference**	**Percentage**
People	3	1	2	66.67%
Sheep and goats	5	3	2	40.00%
Cattle	4	2	2	50.00%
Camel	11	7	4	36.36%
Average	**6**	**3**	**3**	**50.00%**

Table 4.4 shows that the frequency of watering for people and livestock has improved by 50% over the past fifteen years. Chi square test showed a significant association between the frequency of watering days at present and fifteen years ago ($X^2 = 12$, df = 9, p-value = 0.2133). The frequency of water access for people has changed from 3 days to daily basis improving by 66.67%. Frequency for livestock has also improved by 40%, 50% and 36.36% for sheep and goats; cattle and camels respectively.

4.4.3 Distances covered in water acquisition for people and livestock

The study revealed that majority of the households access both water and pasture within a range of 30km from their residence (Figure 4.2). However, a small margin preferred to zero the distance of water (up to 60km from pasturelands) or pasture (up to 70km from water source). Even when there was a permanent source nearby, some households still used a faraway source.

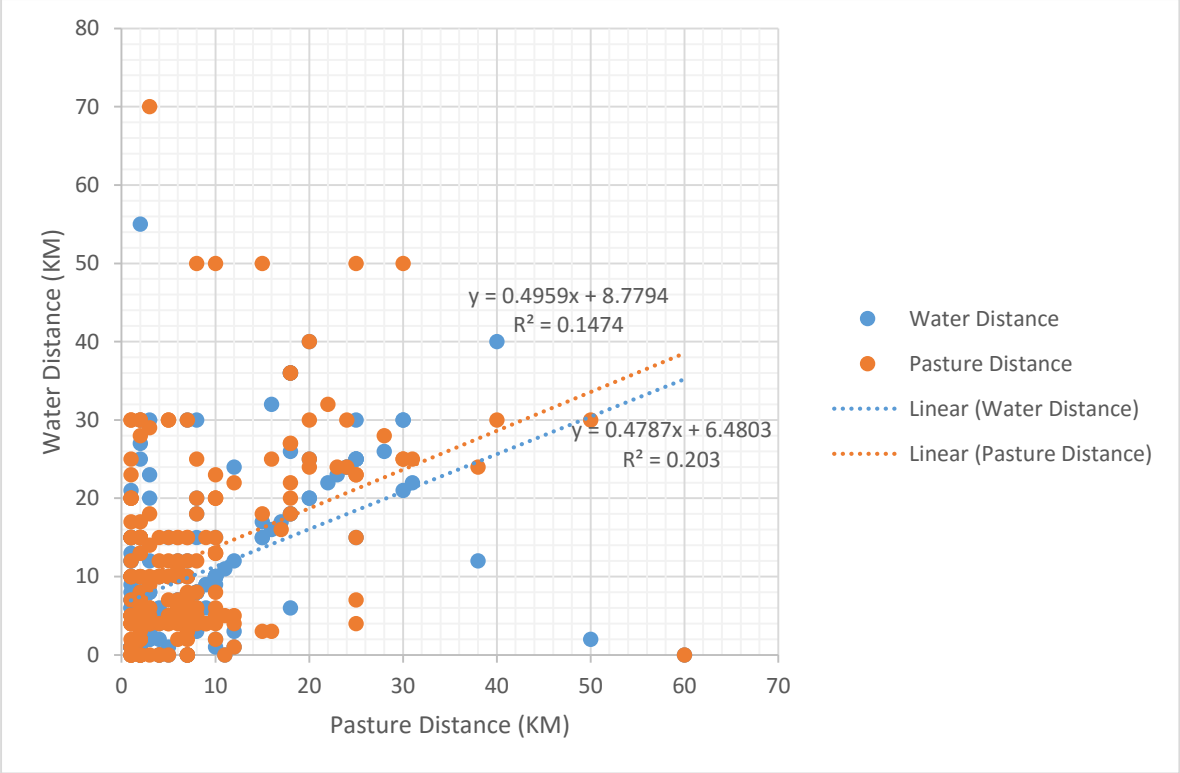

Figure 4.2: Relationship between water and pasture distances

4.4.4 Suitability of accessible water for human consumption

One hundred and fifteen (115, 56%) of the households found the water they use is not safe for human consumption. The sources of water used by each respondent were presented using a bar graph (Figure 4.3).

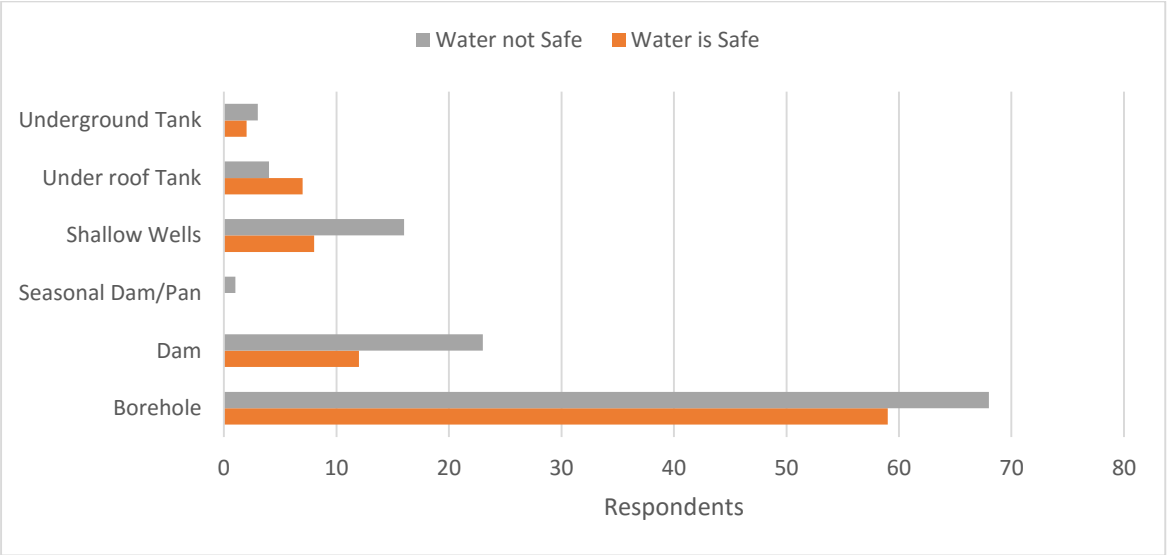

Figure 4.3: Water safety for human consumption by source

Water from underroof tanks was generally found to be safe for human consumption by majority of the households. On the other hand underground tanks, dams, shallow wells and boreholes were all associated with water of low quality that was not safe for human consumption.

4.4.5 Pasture scarcity and actions in pasture shortage

As many as 60% of the households (n=203) have encountered extreme cases of pasture scarcity and have responded in different ways as summarised in Figure 4.4. Forty eight percent of the respondents (48%) reported that they migrated to other areas during pasture shortages (n = 203) while 18% increase grazing distance as pasture recedes and 9% shift or changed their grazing positions. While reactions that involve movement are common among pastoralists, 13% opted to purchase hay from other areas while 6% resorted to God for mercy.

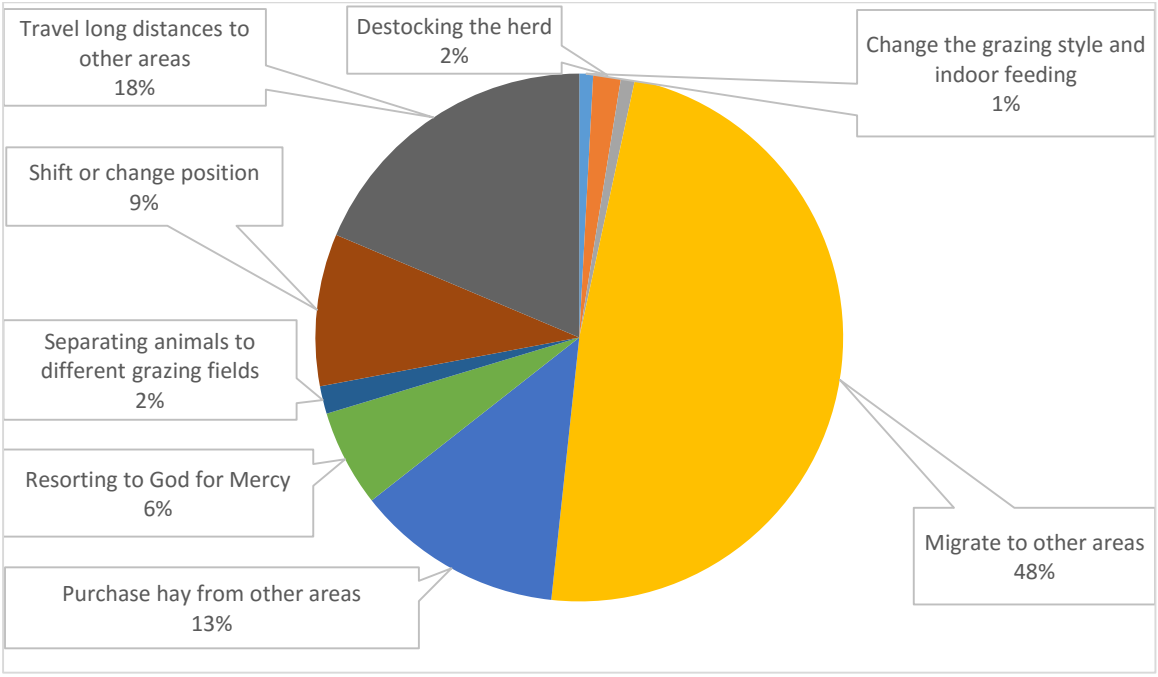

Figure 4.4: Actions taken in exceptional cases of pasture scarcity

4.5 Water and pasture affordability

4.5.1 Means of water acquisition

Water was purchased by 71.9% of the households (n=203) while 28.1% of the residents accessed water freely. The majority of those who purchased water had an access to a borehole while underroof tanks, seasonal dams and earth pans recorded a 100% free

access. Underground tanks and shallow wells were freely accessible to majority of residents as shown in Figure 4.5.

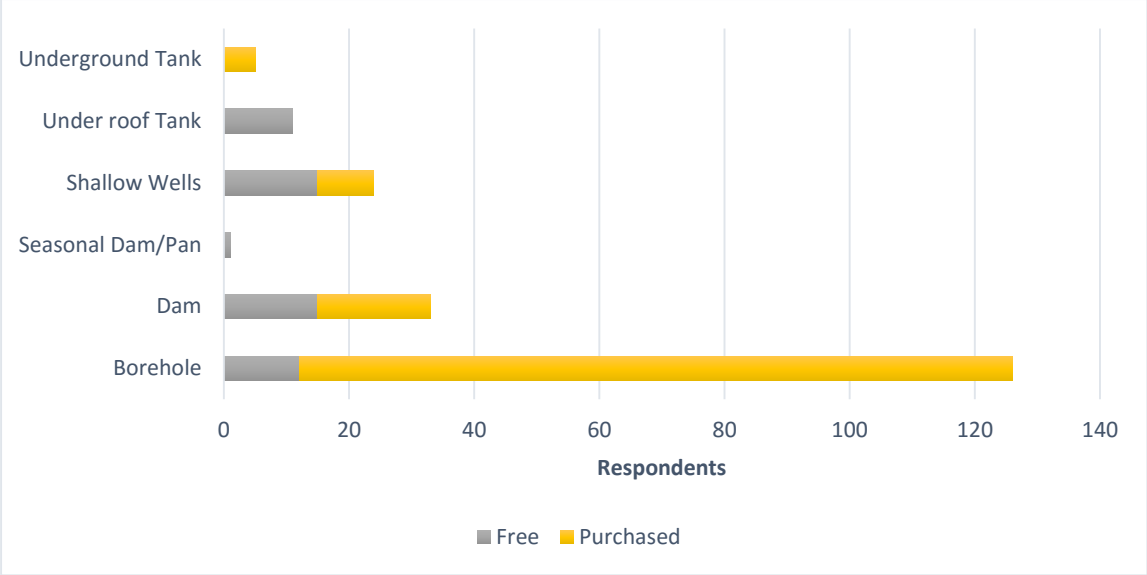

Figure 4.5: Water affordability mode categorised by source

4.5.2 Trends in water costs

Fluctuations in water prices were recorded for both dry and wet season. Figure 4.6 summarises the reasons attributed to changes in water prices.

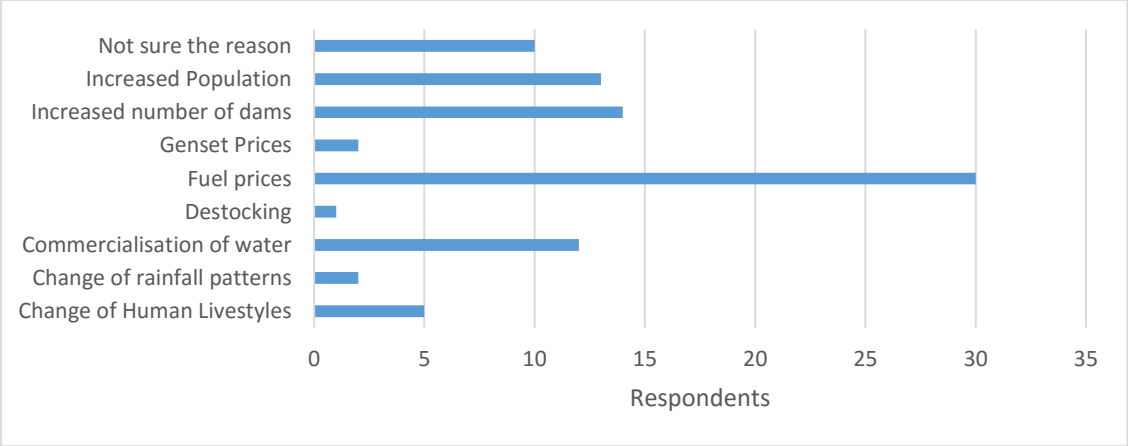

Figure 4.6: Reasons for changes observed in water prices

The study revealed that 114 (51.2%) of the households (n=203) had not witnessed changes on water prices over the past fifteen years. Of those who recorded a change in prices, 33.7% noted an increase in fuel prices while for 13.5% and 14.6%, it was because of introduction of commercial water sources and population increase

respectively. Other results included increase in water sources (15.7%) and changes in human lifestyle (5.6%).

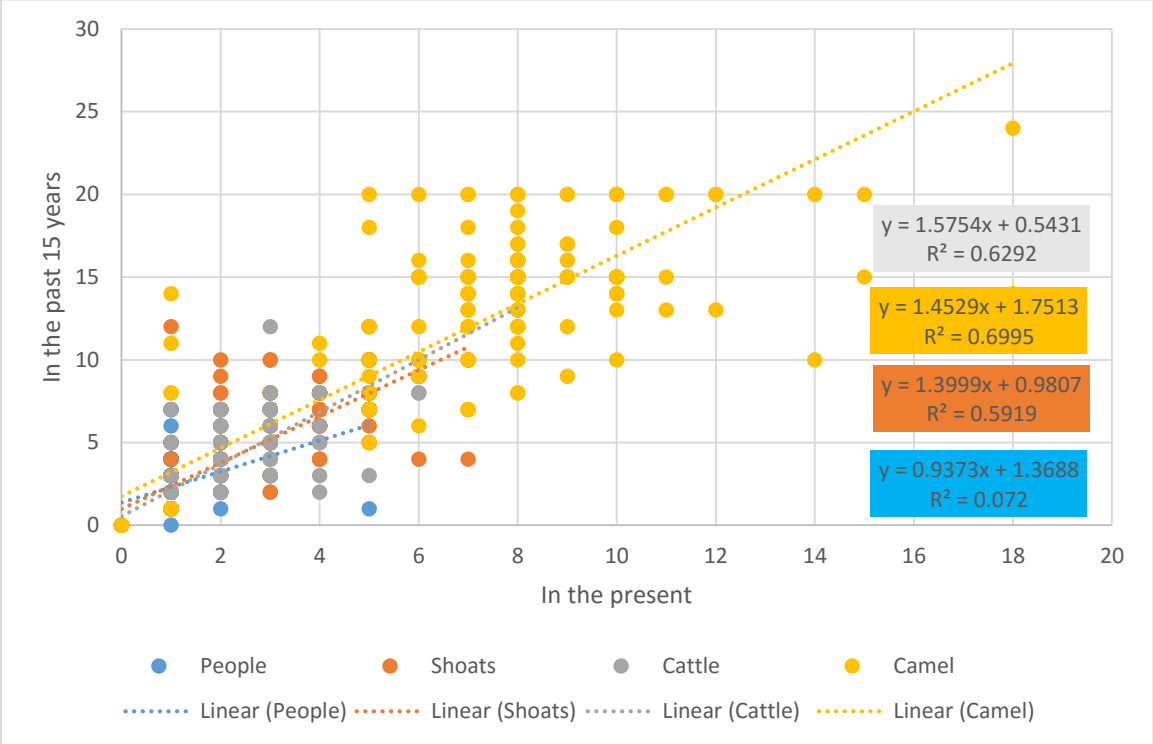

Figure 4.7: Relationships between water cost in the past 15 years and present

The cost of water in the past 15 year was regressed against the cost of water in the present for use by people and livestock. Squared Pearson's product moment correlation coefficient (R^2) was used to test for significance ($p = 0.05$, $n = 203$). The study revealed that prices varied slightly ($r^2 = 0.072$) for people to a relatively higher variation of ($r^2 = 0.5919$), ($r^2 = 0.6292$) and ($r^2 = 0.6995$) for sheep and goats (shoats), cattle and camel respectively. This meant that a higher proportion on variance of water prices for camels in the present was attributable to the variance of water prices for camels in the past fifteen years as compared to that of other livestock and people.

4.5.3 Responses to water and pasture scarcity

A large number of households are prepared to take action in order to access water and pasture resources in case of shortage of funds (69.5%). Majority of them would sell some or all of their livestock to cater for these needs; 20% of them would borrow from family and friends while another 20% would solicit funds from well-wishers. Others included 19%, 8% and 5% who respectively would access the resources at a loan to be

paid to the community water users associations (WUAs), plead with the government for subsidy or abstain from water use occasionally (Figure 4.8).

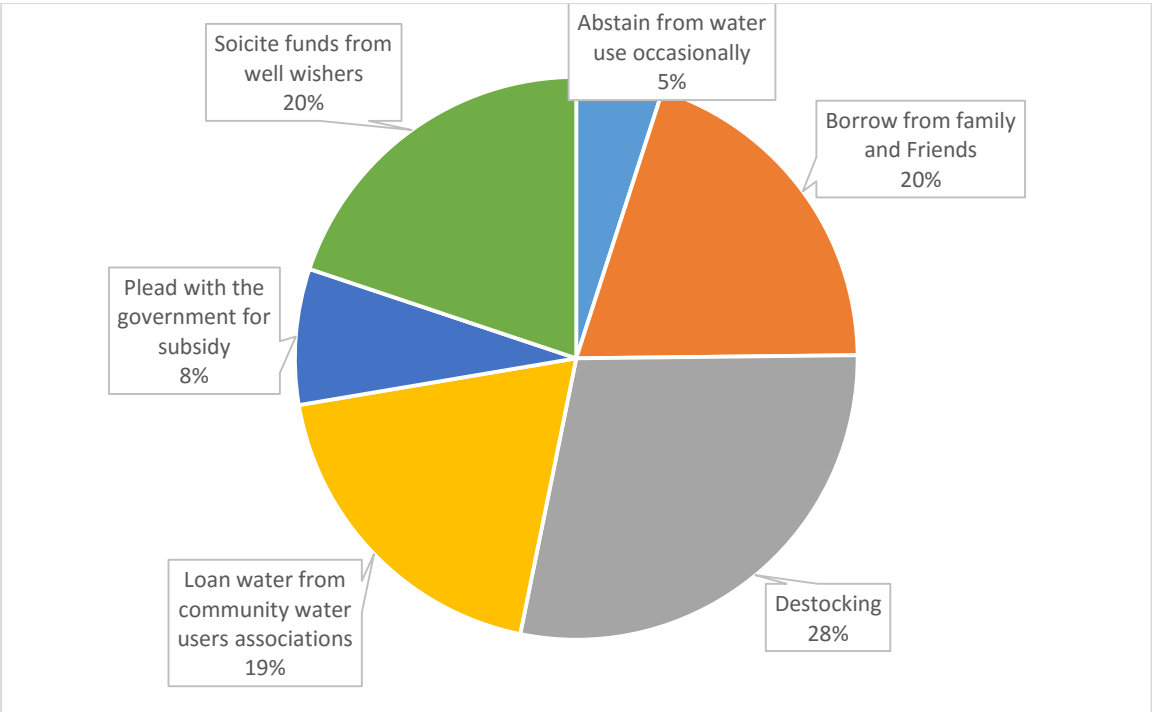

Figure 4.8: Actions taken in case of shortage of funds

4.6 Water and pasture utilization

The study revealed that 52 (34.4%) of households who purchase water have witnessed increase in water availability and changes in water accessibility (Table 4.5). The cost of water has changed in the past 15 years preceding the study period. The table also shows that 13.2% have always been purchasing water (water access has not changed) at the same price (water prices have not changed) and that 64.7% of them have actually witnessed a decrease in water availability. Further, 25 (11.3%) of the residents access water for free, have been accessing the water in the same way and prices have not changed are cheerful that water availability has increased. The study noted that this proportion is rather marginal while the rest are dwindling in challenges.

Table 4.5: Water affordability and price changes, accessibility by availability

Water Affordability	Prices have Changed	Water Access Changed	Total Of Households	Availability Decreased	Availability Increased
Free	Yes	Yes	4	3	1
Free	No	Yes	28	3	25
Free	No	No	18	1	17
Purchased	Yes	Yes	72	20	52
Purchased	Yes	No	13	4	9
Purchased	No	Yes	48	7	41
Purchased	No	No	20	11	9

4.6.1 Management of water and pasture resources when scarce

The study revealed that at least 73% of the residents considered alternatives in case of water scarcity. The rest (27%) would not manage their current stock of animals in case of severe climatic conditions. This was deduced as inadequate resilience to disaster risk reduction (DRR). Figure 4.9 shows that 59.5% of those who would manage scarce water resources considered rationing the little available to both human and livestock while 8.7% would still migrate to other areas.

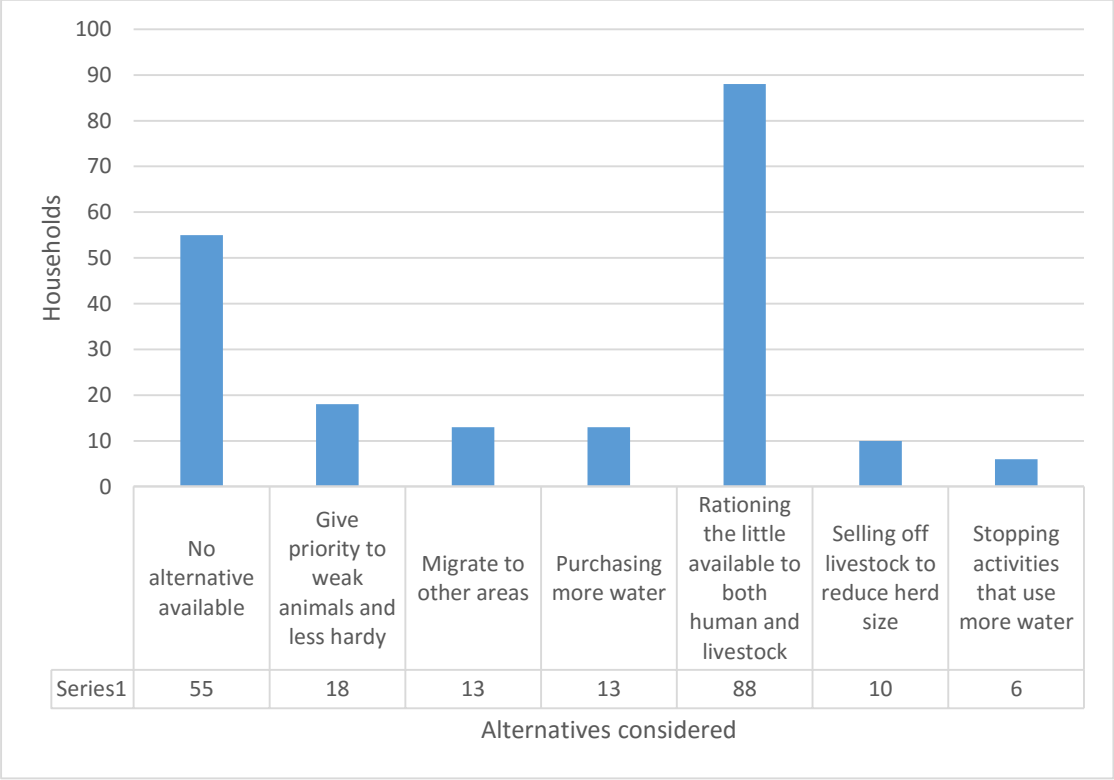

Figure 4.9: Summary of alternatives considered during water scarcity

The study also revealed that managing pasture scarcity was more demanding than water scarcity where as much as 39.9% did not consider any alternative. Nevertheless, the traditional methods such as those involving long distance movement by pastoralist communities were mostly considered. Thirty percent (30%) would migrate with their livestock while 15% and 10% would move to a satellite camp with their livestock or increase the grazing distance respectively. Other alternatives included preserving a portion of pasture for future use, purchasing fodder and hay, sell off livestock, stealing pasture from those who have, underfeeding or rationing pasture and use of alternative grazing methods such as indoor feeding that constituted 5%, 6%, 12%, 1%, 10% and 11% respectively (Figure 4.10).

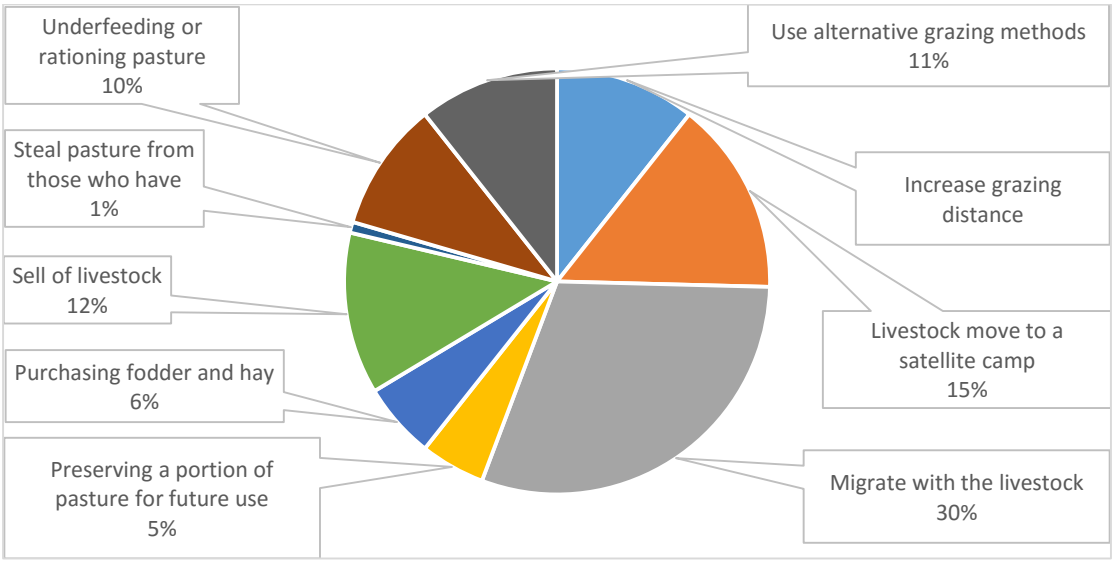

Figure 4.10: Management of pasture resources when plenty

4.6.2 Management of water and pasture resources when plenty

Having plenty of water and pasture, as the study revealed could be challenging. The findings indicated that 40.4% percent would just use the water as opposed to the 2% who would take the opportunity to establish a horticultural or vegetable garden. The study also reveals that 28% would store water in a reservoir when plenty that coincided with 28% who would store fodder when plenty. In Figure 4.11, 38.4% opted not to tell what they would do if there was plenty of pasture. The use of community policies to restrict grazing of livestock very near to a water source as well as from some areas infested with mosquitoes and tsetse flies when put together resulted to 20%. A majority of 34% would just leave the animals to graze freely. The rest 5%, 2% and 11% would

take the advantage to graze in the hard to reach areas, revert to the easier methods of grazing and practise other grazing control measures respectively.

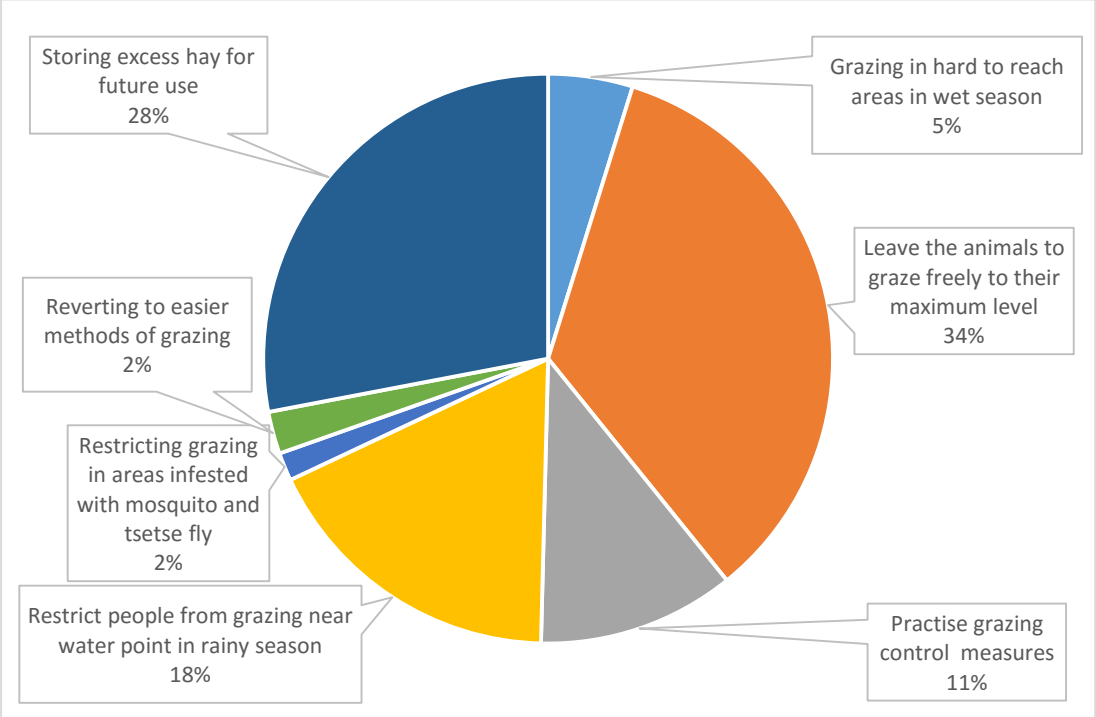

Figure 4.11: Management practises for pasture when plenty

4.7 Climate change and adaptation

4.7.1 Climate change information

The study established that 78.3% have observed changes in the climatic conditions while 62.1% are aware of climate change. The respondents associated environmental changes with changes in rainfall and temperature. Further, the current changes were seen to have negative effects on water and pasture in the study area which threatens pastoral livelihood.

Table 4.6: Information and opinion to climate change

Climate Change Opinion	Total	Accessed Climate Change Information	Not aware of Climate Change
Think that climate has changed	159	114	45
Not Sure that Climate has Changed	44	12	32

In addition to the finding the opinion of the respondents (Table 4.6), the study established consistent change in climate of the study area from 1984 – 2014 (Figure 4.12, Figure 4.13)

4.7.2 Rainfall and temperature patterns

The study revealed that minimum temperature for 1984 - 2014 have oscillated about a monthly mean of 15.8℃ (standard deviation = 0.5442) with the coldest month being July, 1986 that recorded an average of 13.2℃ (Figure 4.12). The maximum temperatures oscillated about a mean of 24.7℃ at a standard deviation of 0.8667 and the hottest month was February 1994 that experienced a monthly average of 28.4℃, followed by 28.1℃ and 28℃ for February 1997 and March 2005 respectively.

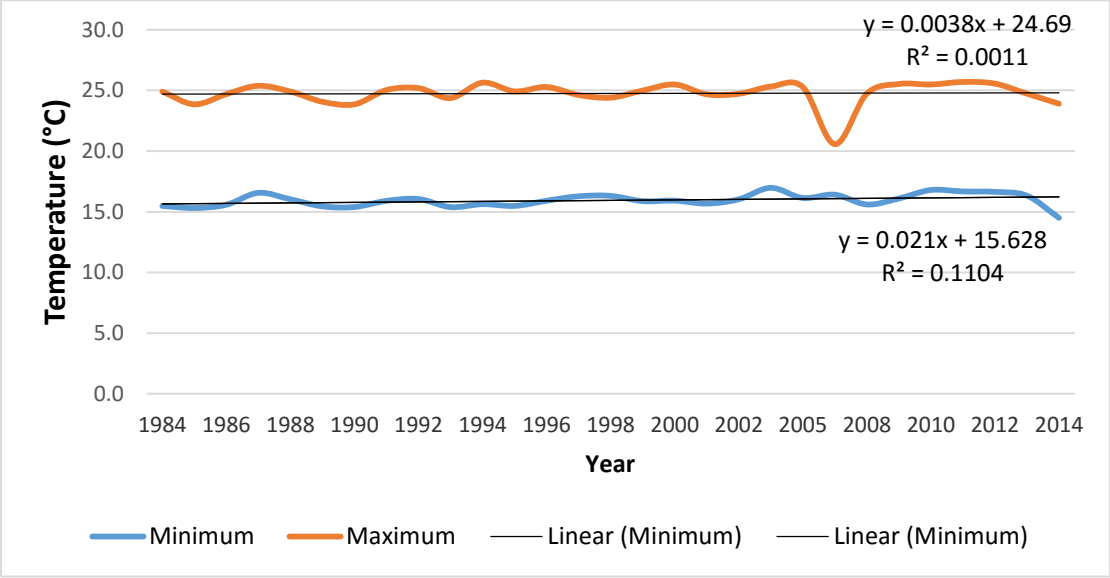

Figure 4.12: Temperature for Marsabit Meteorological Station (1984 – 2014)

Source: Kenya Meteorological Department (September, 2016)

A significant margin was established in the minimum temperature through a line graph that had a gradient of (x = +0.0038, R^2 = 0.0011) while the maximum temperature were observed to have slightly trended upwards (x = +0.0038, R^2 = 0.1104). The study revealed that, rainfall oscillated about a monthly average of 54.5mm with standard variation of 24 (Figure 4.13). The year 1997 recorded the highest rainfall with a monthly average of 120.3 with total rainfall of 1796.7mm between October 1997 and June 1998. Since then, rainfall reduced significant until a peak in 2000 which recorded a monthly average of 8.3mm (Figure 4.13). The study showed that with exception of

November, all other months in 2000 received less than 15mm of rainfall. Rainfall trended with a gradient of (x = -0.0666, R^2 = 0.0005).

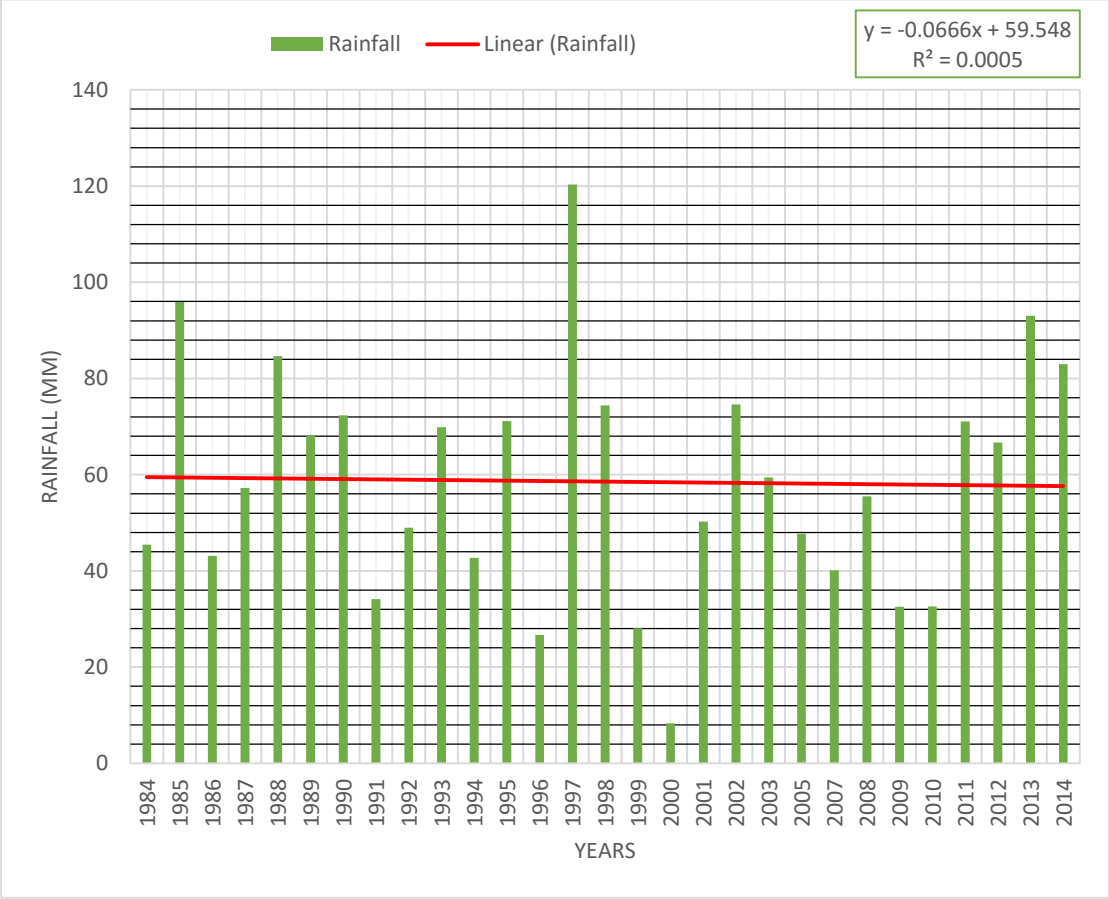

Figure 4.13: Rainfall for Marsabit Meteorological Station (1984 – 2014)

Source: Kenya Meteorological Department (September, 2016)

A close study at a period of four years running from 1997 to 2000 showed that change in rainfall has been more pronounced (R^2 = 0.9724) with a gradient of (x = -38.24). Noteworthy, 1997 was a period of El Niño which recorded the highest rainfall and was followed by La Nina in 1998/99 characterised with extremely low rainfall (Figure 4.14). The wettest year in the past 30 years was 1997 and in the extended period 1982 while the driest was 2000 that had a monthly average -51 mm below average. It is not new in Marsabit for a month to record no rainfall, where up to 30 months recorded a zero, which when added up are two and a half rainless years while 41.2% of the months in that period received less than 10mm of rainfall. Rainfall differed widely by season across years (Figure 4.15).

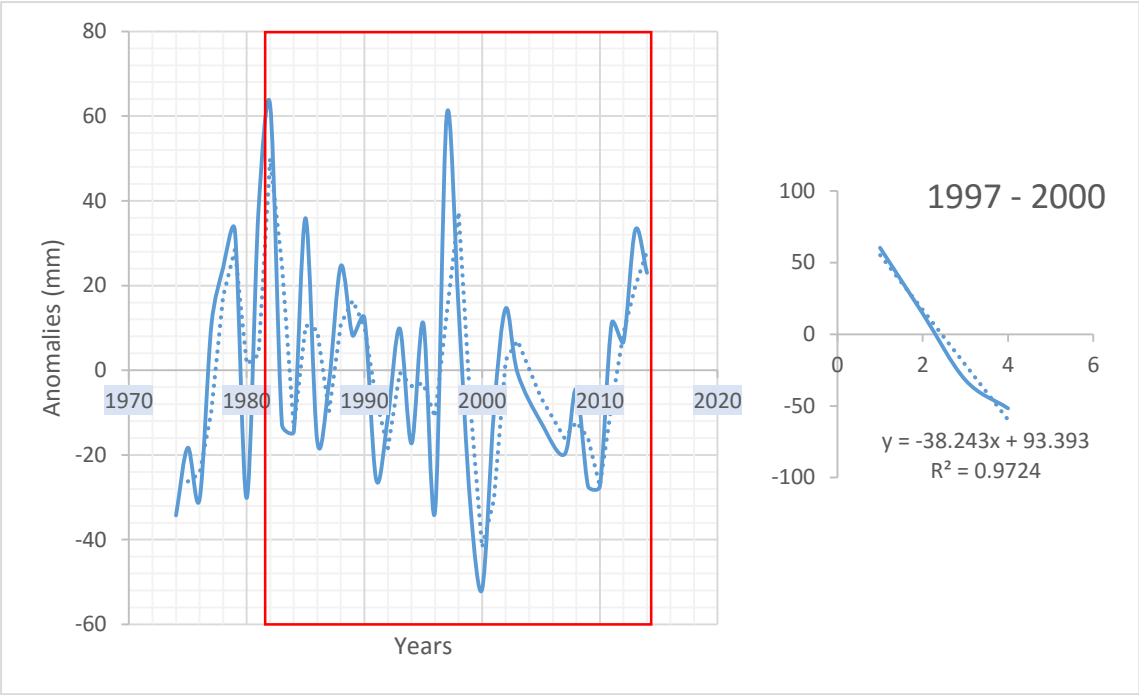

Figure 4.14: Deviation in Marsabit rainfall from monthly average (1974 – 2014)

Source: Kenya Meteorological Department (September, 2016)

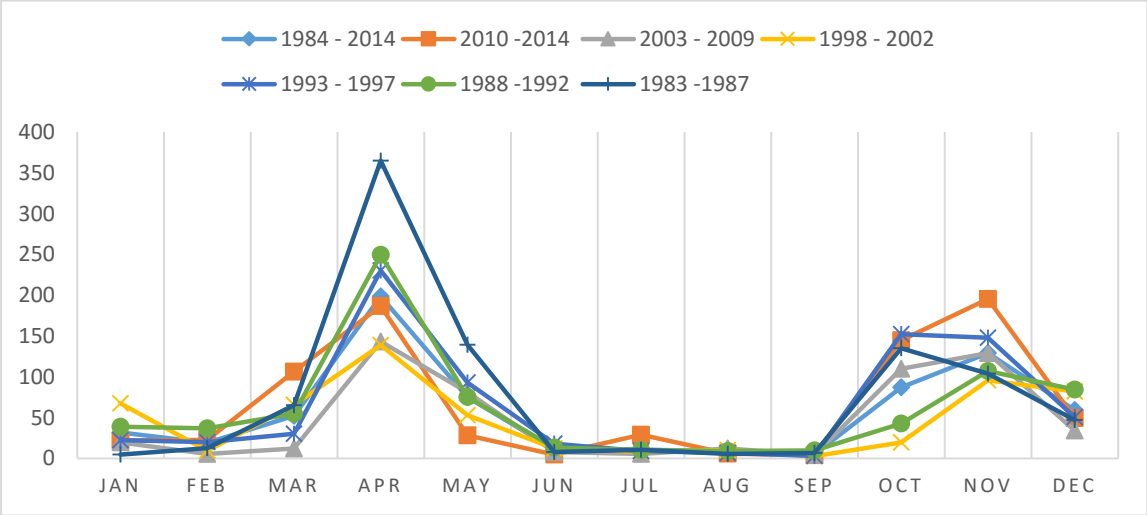

Figure 4.15: Trend in rainfall seasons for Marsabit Met Station (1984 – 2014)

Source: Kenya Meteorological Department (September, 2016)

Rainfall is characteristically bimodal (Figure 4.15) despite slight observable intra-annual variations. Annual monthly average was done in seven cohorts of 5 years since 1983 with exception of missing data for 2004. Two distinct seasons dominate, between March, April to May (MAM) and October, November to December (OND) except for 1997 where, the El Niño extended to merge with the subsequent season in 1998.

Majority of the households described rainfall in four languages; Unsystematic rainfall patterns, rains of low intensity, sparsely distributed rains and unpredictable rainfall seasons (Figure 4.16). These included 63%, 55%, 75% and 50% respectively.

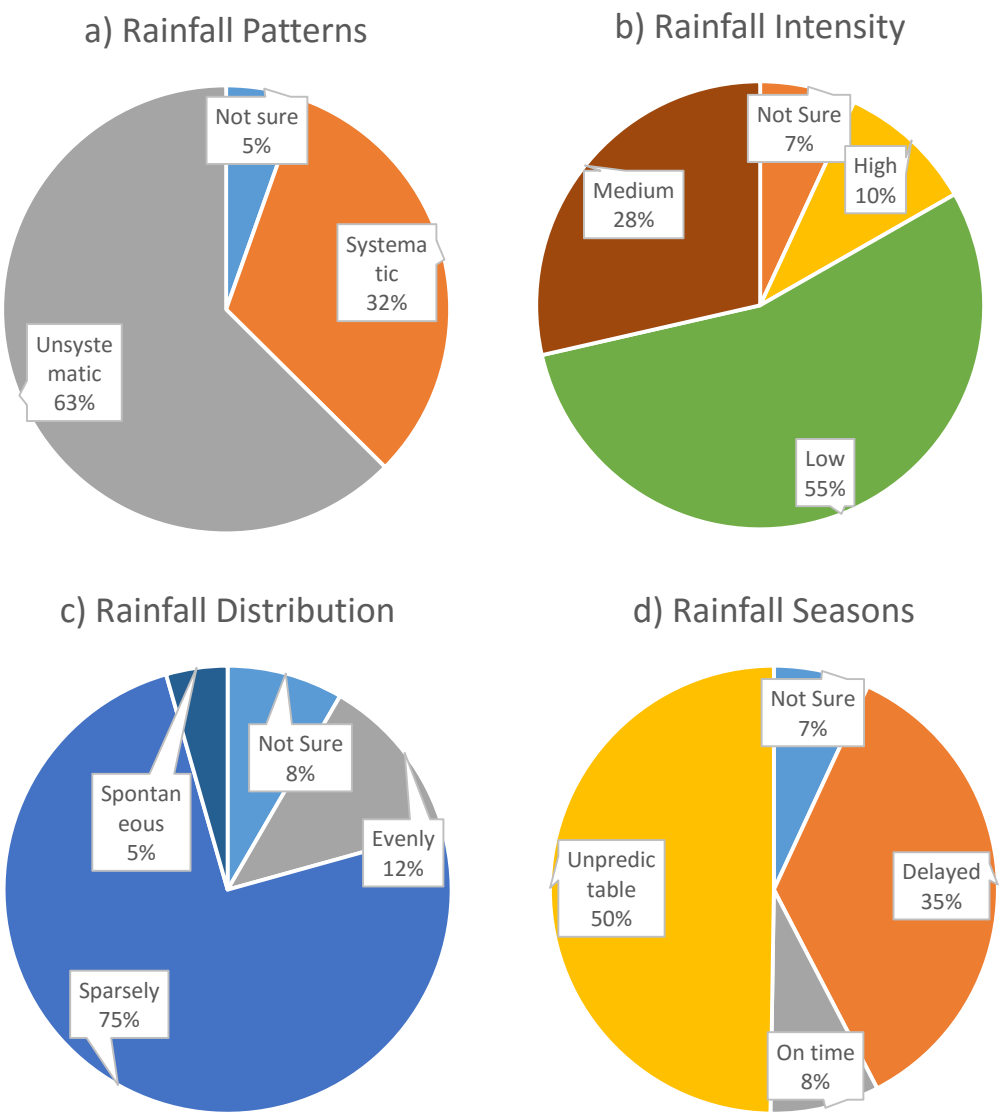

Figure 4.16: Division's rainfall patterns, intensity, distributions and seasons

It is alternatively observed that there is direct relationship between increased rainfall to pasture and water availability and vice versa. In figure 4.16, the repondents also described rainfall patterns as systematic (32%), rainfall intensity as medium (28%) or high (10%), rainfall distribution as spontaneous (5%) or even (7%); while rainfall seasons were also described as delayed (35%) or timely (8%). The responses were also given regarding the effects of extreme environmental conditions (Figure 4.17).

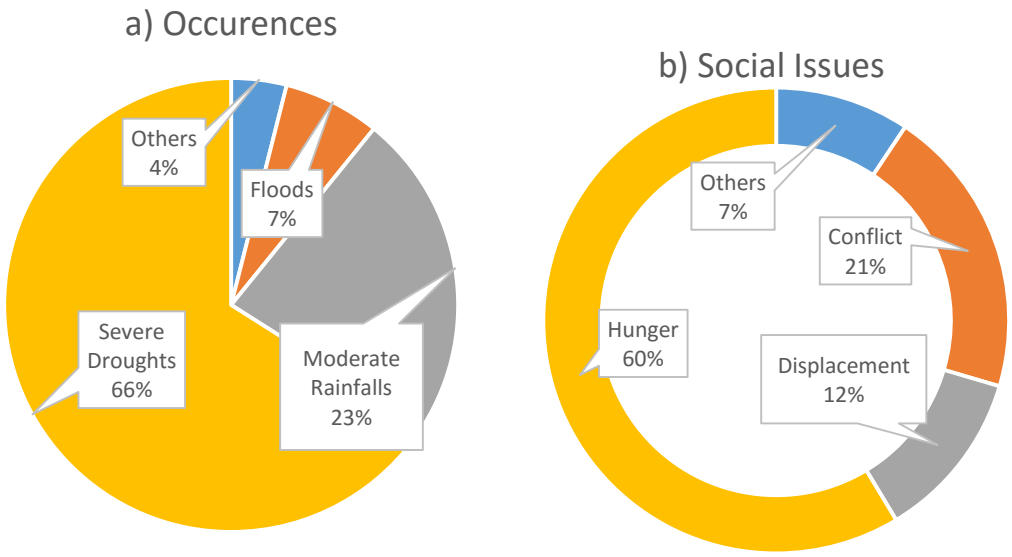

Figure 4.17: Social issues associated with harsh climatic conditions

The households noted that severe climatic conditions were associated with social issues (Figure 4.17b). Social issues were identified as mainly hunger, conflicts and displacement at a ratio of 20:7:4 while other issues described were 7%. Severe droughts were the most common occurrence that was witnessed by 2:3 of the households and 23% observed reduction in the rainfall while an eighth of the households observed floods or other severe climatic conditions (Figure 4.17a).

The majority of those who have observed floods (50%) and other severe climatic conditions (50%) have lived in the study area for approximately 5 years or less (Table 4.7). Those who have lived for approximately 10 years noted reduction in rainfall (32%). Majority of the residents who associated extreme environmental conditions with occurrence of severe droughts (n = 134), out of whom 29.1% have lived in the area for approximately 20 years.

Table 4.7: Observed severe climatic conditions by length of stay in the study area

Extreme Climates	0 - 5	6 - 10	11 - 15	16 – 20 +	Total
Floods	7	4	1	2	14
Moderate Rainfalls	10	15	12	10	47
Severe Droughts	35	36	24	39	134
Others	4	1	2	1	8

The study further established a wide range of indicators of severe climatic conditions as described by the households (Figure 4.18). It was noted that 24% observed that

increased distances to water points were as a result of severe climatic conditions (n = 203). Further, 22% observed degraded pasturelands and 18% noted that loss of livestock widened poverty level in the region which was as a result of severe droughts. Other observations include severe soil erosion by wind and floods, increased aridity, desertification and disappearance of indigenous vegetation. It was noted that as a survival strategy, some respondents decamped to wetlands and mountain areas while others opted to widen their water to pasture distance. On the contrary, a few reverted to raiding as a means of restocking thus causing conflicts.

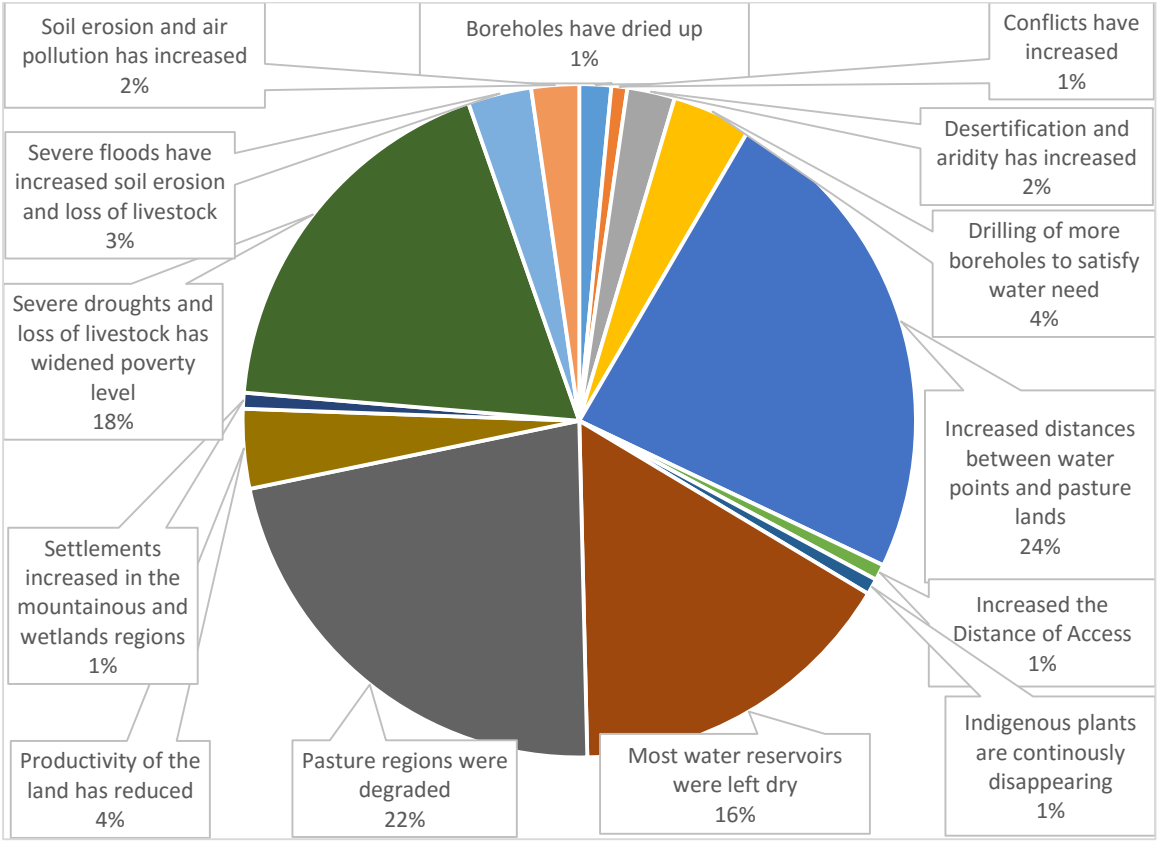

Figure 4.18: Indicators of severe climatic conditions

4.7.3 Adaptation strategies

The study revealed that 55% of the respondents have observed changes in rainfall patterns (n = 162) while 21%, 15% and 9% have observed changes in temperature, sunshine intensity and cloud cover respectively. When faced with these harsh climatic conditions, 75% of the households would migrate to other areas (Figure 4.19). In addition, 12% would seek assistance from the government, 11% would resolve to purchasing fodder or water while 2% would steal from those who have.

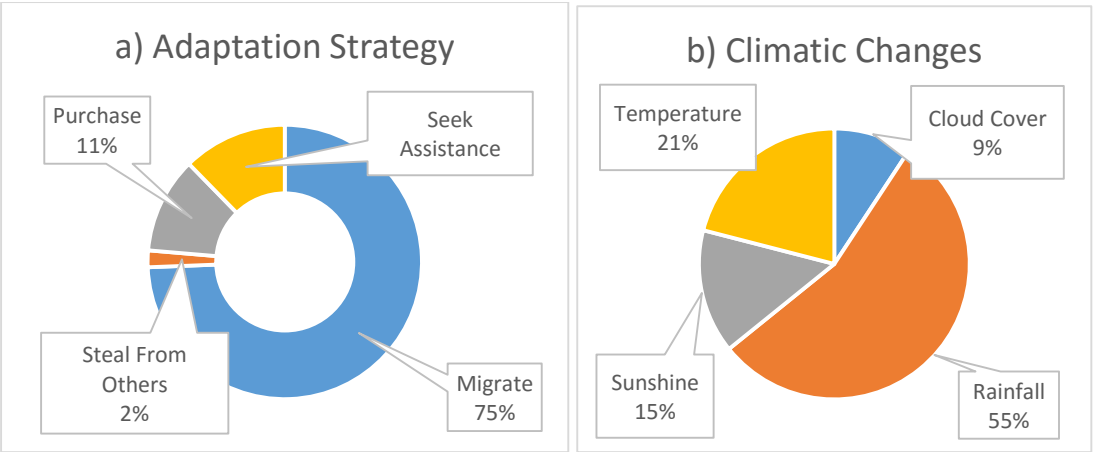

Figure 4.19: Adaptation strategies during severe climatic conditions

4.7.4 Pasture and livestock management

It has been known that drought resistant animals such as camels would go for many days without water. Nine adaptive traits developed by (Megersa, 2013) that included tolerance to water scarcity, feed shortage, heat stress, drought tolerance, coping with bush encroachment and walking ability showed that camels were the most adaptive. However, 44.8% have noted changes in this trend, some attributing it to increased or reduced quantities in water and pasture or reduced quality (Figure 4.20). For instance water availability and accessibility has improved as noted earlier in this chapter even when some remarked that the water lacks various minerals in current water sources. Climate variability and high temperatures were blamed for these changes. The reasons why livestock resistant to harsh climatic conditions have changed was as a result of disappearance of some important plants species that were traditionally essential to the livestock diet and general shortage of pasture.

Plant species that are disappearing were highlighted by the households. These included *Ormocarpum trichocarpum* (Butiye), *Blepharis* spp. (Barrat), *Cadaba mirabilis* (Qathu), *Acacia drepanolobium* (Fulles) and *Asparagus spp*. (Barambaru, Okolle). The findings of this study corresponded to the study by Dabasso, Oba, & Roba (2012) who using the indigenous knowledge of the herders in Marsabit Central, identified a wide range of plants that are decreasing. In the same study, some species were increasing which coupled with the study by Lelenguyah (2013) on effects of climate variability on pastoral livelihoods in Marigat raises concerns on the impacts and economic costs of invasive species to pasture scarcity (SEI, 2009).

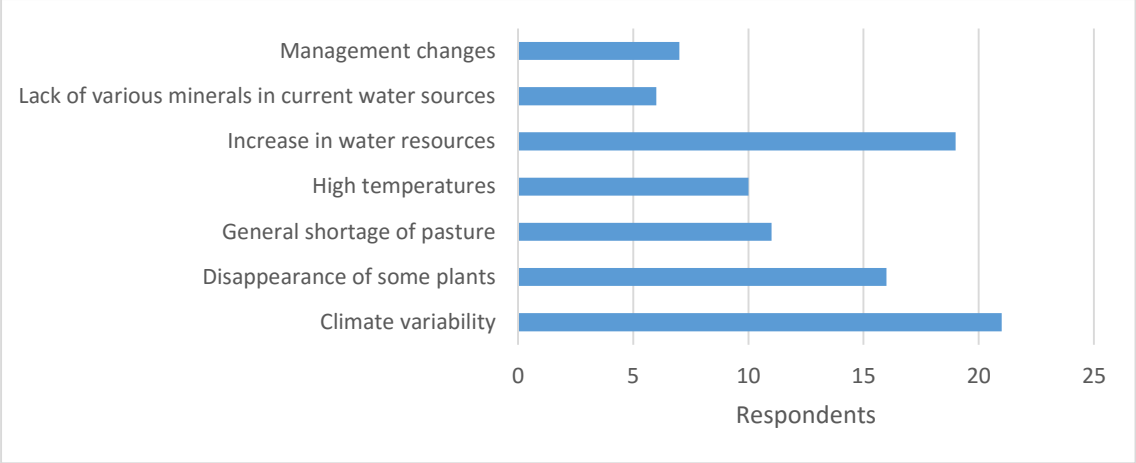

Figure 4.20: Reasons why drought resistant animals have changed

The study found out that only 42.9% would manage their current livestock (n = 203). Of those who would manage, 37.9% would do it by destocking or reducing the number of the stock. Those who reported that they would not manage their livestock attributed this to lack of adequate funds and the large herd they kept 7.8% and 14.7% respectively. 12.9% of the respondents were not prepared for any disaster that would have arisen by the time of this study. The results, in a scale of 1 were indexed in Table 4.8.

Table 4.8: Reasons why the respondent would or not manage their current herd

Management Practice	Description	Cluster	Proportion	Rank
Destocking some or all livestock	Adaptation	1.156	0.384	1.000
Purchase water or fodder	Adaptation	0.579	0.192	0.750
Seeking Expert Assistance	Adaptation	0.579	0.192	0.750
Diversify Grazing Methods	Adaptation	0.469	0.156	0.250
Migrating or zero pasture distances	Adaptation	0.226	0.075	0.000
Overstocking and Overgrazing	Challenge	0.876	0.301	1.000
Disaster Unpreparedness	Challenge	0.751	0.258	0.750
Poor Planning for Range Management	Challenge	0.575	0.198	0.500
Inadequate Funds and Poverty	Challenge	0.529	0.182	0.250
Water and Pasture Scarcity	Challenge	0.177	0.061	0.000

4.7.5 Role of stakeholders

Different stakeholders such as government agencies, religious and humanitarian organisations were found to have played a pivotal role in supporting the local people to climate change adaptation in respect to water and pasture. These were either livestock

based roles such as mitigation of impacts by providing emergency feeds, fodder production and provision, restocking and introduction of drought resistant species as well as water based roles such as water trucking, drilling of boreholes and provision of gen sets. Drilling of boreholes by stakeholders had been witnessed by 54% of the households while restocking and provision of forage by 14% (Figure 4.21).

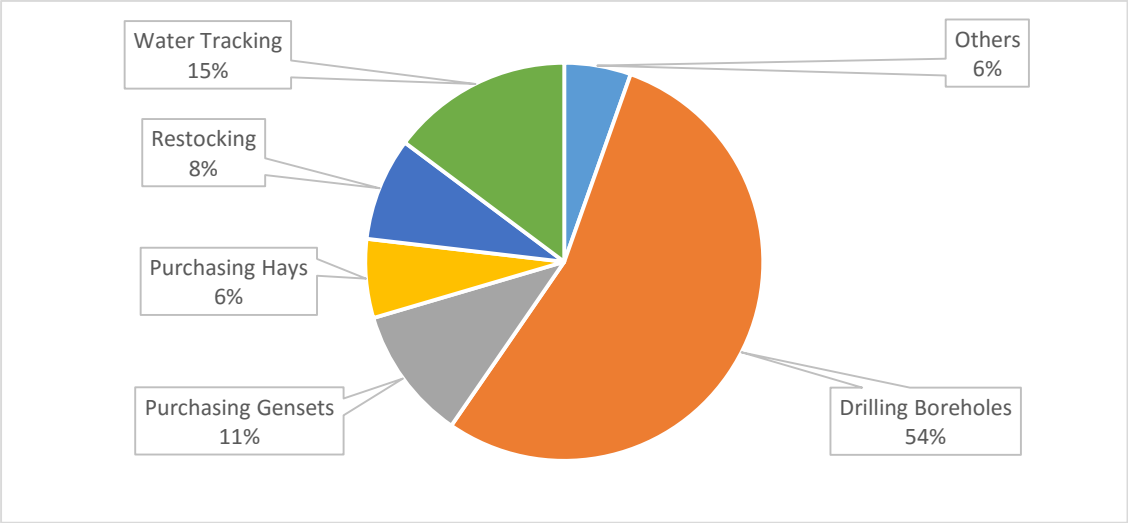

Figure 4.21: Roles of stakeholders in water and pasture provision

6% of the respondents noted that stakeholders were engaged in alerting the people during severe climatic conditions, which was taken as disaster risk reduction (DRR) and assessment. Many boreholes and earth pans were constructed by local NGOs, the County and the National Governments including the Constituency Development Funds (CDF). In Burgabo, 3 boreholes along Marsabit – Moyale Road were drilled by a Chinese road construction company (ACTED, 2011). The findings also agree with Robinson (2009) who through his study at Pastoralists Integrated Support Programme (PISP) in Turbi reported that the organisation has been engaged in emergency water trucking since 1996 when it was founded. The identified government role goes hand in hand with a study done by (CDC, *et al*., 2009) and; backed up by (Mude, *et al*., 2007) who found that community water users associations were supported by the government to improve management of ASALs.

4.7.6 Policies and frameworks in adaptation to climate change

Those who have encountered extreme cases of pasture scarcity have responded in different ways to their own vulnerability (Table 4.9).

Table 4. 9: Frameworks available to affected Pastoralists

Has been in Exceptional Cases of Pasture Scarcity	Total	No Framework Available	Drought Resistant Species	Livestock Diversification
Yes	117	28	41	48
No	86	50	15	21

It was established in table 4.9 that 117 (76.6%) of the respondents have since accessed some form of adaptation framework including livestock diversification and introduction of drought resistant species (n=203). However, 50 (58.1%) of those who have not yet encountered exceptional cases of pasture scarcity still dwell in the comfort zone and have been reluctant to adopt any adaptation framework. A relatively small portion of those who have adaptation frameworks and policies also noted that there have been policies for destocking and setting aside pieces of land for use during the dry period of pasture scarcity. Notably, the households reported that sometimes it was out of their voluntary initiatives that they resorted to drought resistant species like camels and destocking in order to keep a manageable number that can sustain the household without degrading the environment.

4.7.7 Community recommendations for resource management

The study sought to collect information on what the households would have wished to do but was not within their reach. A wide range of responses were collected and further categorized into 20 recommendations in six clusters. The households expressed their interests in the use of modern livestock production methods, paddocking, collective destocking by the community and improved market for livestock and livestock products 26%. Other proposed complementary strategies included construction of water sources such as boreholes in the fall back areas and along the river beds as well as more improved water sources and storage of water in reservoirs in strategic places which added up to 44.1% as well as 3.9% for capacity building and educational programs for farmers of livestock management, rangeland management and climate change. A smaller percentage of 5.9% expressed interests in diversification to other livelihoods outside pastoralism and agro-pastoralism, such as agriculture, formation of ranches and

fencing of large pasture lands to be utilized during severe climatic conditions while 15.6% or the residents believe that reclamation of waste lands for commercial production and storage of fodder including rangeland reforestation could change their lives forever.

4.8 Findings from key informants

The study engaged seven key informants. They included two (2) from government agencies based on their technical expertise, one local chief, two (2) from local NGOs and two chairpersons of WUAs. All the informants described the climate of Turbi Division as semi-arid that is hot, dry and windy most of the times. Some areas have grasslands and small hills and the rains are received in March to May (MAM) and October to December (OND). The rains are untimely and not well distributed, are erratic and unreliable but not entirely unavailable.

4.8.1 Observed climate variability

The informants noted that the frequency of dry season had increased with depressed rainfall and that the number of wet days had reduced with change in onsets of seasonal rains. Temperatures were observed to have risen and the frequency of droughts had changed to between 2 to 3 years as opposed to 5 to 9 years in the past. It was observed that this had led to disappearance of some plant species which was further described by one of the informants that, "*There are more livestock and more watering points and vegetation is deteriorating".* Notably, all informants attributed these trends to climate change and variability coupled with human activities such as deforestation, overstocking, land degradation and sedentary settlement near permanent water sources.

4.8.2 Pastoralists and climate adaptation

It was noted that due to overgrazing and scarce water, sometimes pastoralists are affected negatively even leading to loss of livestock. It was revealed that pastoralist trucked water over long distances and increased watering points during the extremely dry seasons. As noted by one of the informants, "*During these frequent droughts, animal morbidity is more pronounced, making it difficult for pastoralist communities to access milk, blood and meat when they are is most required."* This aggravated dependency on aid, relief food and donations. Another respondent noted that, "*The regions that were once known for high water yields have decreased or permanently*

dried up, while areas that used to be pasture rich no longer rejuvenate pasture. The pastoralists are in constant migration to closer proximity of water and pasture." Pasture was observed to have reduced in some areas due to high grazing pressure while water increased with devolution when more boreholes and dams were constructed. However, provision of water has become expensive because the water table had gone down for boreholes while due to the increased level of evaporation, water pans hardly collect enough water to sustain the increasing livestock and human population.

Two key informants were engaged in formal research work that relates to this study. This included range monitoring which is conducted frequently depending on the availability of funds and the other is research in the field of animal science and veterinary medicine. In the field of range management, research has improved traditional systems of grazing as well as monitoring areas that were enclosed during rainy season for use in the dry season. Such enclosed rangelands allowed regeneration of seeds in some watering points before grazing on them in order to build up seed bank reserve. Use of conventional veterinary medicines in the treatment of new and emerging diseases has also been made available to pastoralists as well as upgrading of local livestock breeds to more drought and disease tolerant breeds with increased productivity. The research findings are made available through extension workers, public barazas, agricultural shows and FGDs during dissemination of livestock technologies. The informants noted that issues of concern in the county are closely related. These findings concurred with a study by ILRI on climate change adaptation in Marsabit which revealed that water and pasture scarcity were only a part of other concerns and can be addressed (Mude, *et al*., 2007).

Numerous conventional water and pasture stress adaptation strategies practised by pastoralists in Turbi Division were identified by the key informants. They included restricting use of water in pans and boreholes during rainy season until surface runoff has been exhausted. Strategic water points have been established in fall-back areas and preserved to be used during critical times only. Controlling the number of livestock that access the pans and boreholes and paying infrastructure maintenance fees helped to increase water availability for a longer period. Using rangelands management and traditional grazing patterns, one key informant noted that it helped minimise water usage and livestock watering intervals. Other strategies included shifting of the main

herds to far flung areas while the sheep and goats utilise the little available resources near the homestead. Further, water trucking, grazing management through Environmental Management Committees (EMCs), use of earth pans along catchments, purchasing hay and supplementary feeds in times of scarcity were identified.

Further to having the aforementioned conventional adaptation mechanisms in place for the pastoralist communities, it was noted that they are still faced with many challenges and threats. Challenges noted included reduced grazing lands, low water distribution, new emerging livestock and zoonotic diseases, lack of proper livestock market without regulations, hostilities among the migrating communities, and theft of livestock from other communities, overstocking that leads to overgrazing and disappearance of forage and pasture species. Consequently, the pastoralist communities are under constant threat of loss of livestock as a result of drought, loss of life through livestock rustling and insecurities arising from pasture and water conflicts and malnutrition arising from areas where people cannot access balanced diets.

In addition to the conventional strategies, the informants recommended relevant strategies that would help pastoralists adapt to climate change as reported by one of the respondents, "*We encourage the communities to reduce the number of herds in order to control overgrazing and to adopt climate smart technologies in livestock keeping."* It was also noted that, "*Keeping livestock for market is more appropriate that for prestige and other traditional purposes."* Other relevant adaptation strategies identified included milk preservation technologies, value addition for meat and milk for prolonged shelf life, harvesting of hay and bulking for use during the dry spell and rehabilitation of rangelands through range reseeding. It was also a concern that some of these coping mechanisms are very expensive and also very unsustainable.

4.8.3 Stakeholders' engagement in climate adaptation

The key informant emphasised on the role of government and other stakeholders in the dissemination of information on impacts of climate change and adaptation. Recommendations such as trainings on climate smart technologies, environmental conservation and climate change adaptation strategies were made. One key informant noted that, "*Provision of water alone, without means of managing livestock sizes is like destroying the communities' adaptation to climate change; it is a threat to an already*

fragile rangeland management ecosystem due to the risk of overgrazing." Destocking programmes are important in reducing large livestock herds if coupled with improving livestock market and encouraging livestock owners to take market access. Further, institution of EMCs in order to safeguard vegetation cover, rangeland planning as well as range reseeding were identified as roles of stakeholders. In an attempt to reduce hostilities among pastoralist communities, the stakeholders were held responsible to exchange peace meetings for the people to share pasture during drought periods.

In order to make pastoralism sustainable in the advent of climate change, the key stakeholders proposed recommendations to the government. These included ensuring adequate and timely dissemination of information on climate change, adaptation strategies and mitigation measures to pastoralist communities. They also encourages research on better coping mechanisms to be conducted. Further recommendations were on promotion of peaceful coexistence between tribes through encouraging peace building initiatives and provision of security to pastoralists. The informants recommended technology adaptation and transfer of modern pasture growing methods. Diversification and improvement of livestock breeds were also proposed. Commercialisation of pastoralism through breed improvement to strengthen the existing livestock markets were emphasised. Index-based livestock insurance (IBLI) and voluntary commercial off-take of livestock were note to mitigate total loss during drought. Further, the informants urged the stakeholder to encourage the use of Information and Communication Technology (ICT) including GIS, Normalized Difference Vegetation Index (NDVI) to assist in rangeland resource management. Finally, other indirect inputs such as educational programmes in health, reproductive health, drug abuse and emphasis on the education for pastoralist children through provision of boarding facilities were highlighted.

4.9 Results for focus group discussions

FGDs were carried out in four locations comprising members of the WUAs and opinion leaders in the community. All discussions pointed out that even when water increases pasture resources are continuously diminishing while both human and livestock population increases. All the four FGDs noted that rainfall has reduced as the intensity of droughts increased. The little rain received in some regions is not uniformly distributed.

Some opinion leaders alleged that Chalbi Desert has completely stopped receiving rainfall while in other regions it has drastically reduced. It was also noted that once it rains, it takes a long time before it rains again. Therefore, all the water is evaporated by the end of rainy season and very little is saved in reservoirs. Likewise, temperatures were expressed as relatively high with very cold nights accompanied with strong wind storms. An opinion leader pointed out that, "*Pasture dries immediately after rainfall ceases due to high temperatures. For instance the year 1994 has been named ('athu owitu' - meaning the year of hot sun). Extreme temperatures were experienced in that year and since then ('fites' – morning grass due) was completely lost."* Most of these changes were as a result of continued destruction of the environment including cutting down of plants for pasture, construction of houses and harnessing resources.

Further, extended climate variability was said to be as a result of disagreement on human ideas especially in decision making. Over-exploitation of resources by humans as well as overstocking of livestock were pointed out as leading factors. Additional factors included use of fossil fuels, population increase, and pollution of the environment and bush fires. Consequently, disappearance of plants of pasture species that were very useful to the livestock had been observed as well as reduction in wild fruits that pastoralists depend on, few young plants regenerate due to severe and frequent droughts. The groups identified that due to water scarcity, more water resources have been established such as boreholes, underground tanks and dams. Natural rock catchments in Turbi Location such as Chanchali and Qachale are diminishing while Matho athi, El Dadhacha, Matho Chuna and Chopi Qote have completely dried up. Bales Adano and Bales Arilo in Bubisa Location have dried up.

The floods that occurred in the region were still fresh in the minds of people. A news article by flood archive on 20th March 2008 reads, *"Rainy season begins in Kenya: Overnight downpours kill 2 in Marsabit District, entire Bubisa Village, Bubisa Area (population 2,000) swept away by floods and several dead in Chalbi!"* (FloodArchive, 2008). Further, the FGDs noted that soil erosion was caused by both rainfall and strong winds. Rainfall that is often accompanied by strong wind storms is more violent. However, worst still is the frequent droughts which have been known to kill a lot of livestock and deplete all pasture resources. When coupled with the increasing temperatures, animals become dehydrated, pasture are scarce and livestock mobility

increase severely. The little available water and pasture resources are often overcrowded leading to overuse and environmental degradation. Finally, it was noted that with the changing climate, water quality has also changed while household consumption for both people and livestock has increased.

4.10 Relationship between traditional and conventional adaptation strategies

The theoretical framework postulated that major changes in the climate are likely to result to evolution of adaptation strategies and influences external forces to intervene. As aforementioned, climate variability has been met with many adjustments by the communities in Turbi Division, which include both traditional and conventional adaptation strategies. Traditional strategies included migration, destocking, herd management, religious practices, sharing water with others, using traditional weather forecasting methods, herd diversification, forming alliances with other communities and using restrictions to control water resources (Table 4.10). The study revealed that traditional adaptation strategies differed significantly from the hypothetical mean (μ=1.9751, t = 2.183, df = 6, p-value = 0.0718).

Table 4.10: Summary of traditional adaptation strategies by cluster

Traditional adaptation strategies	Cluster	Proportion	Rank
Migrate (With livestock or satellite camp)	6.848	0.495	1.000
Destocking (All the herd or a section)	3.427	0.248	0.833
Leave the animals to graze freely	1.230	0.089	0.667
Grazing in hard to reach areas in wet season	0.902	0.065	0.500
Rationing for both human and livestock	0.631	0.046	0.333
Resorting to God for Mercy	0.488	0.035	0.167
Abstain from water use occasionally	0.300	0.022	0.000

When discussing the new initiatives that are currently available for adaptation to water and pasture scarcity, it was revealed that the community is establishing pasture ranches. This is completely a new concept in the study area. Notwithstanding, the adaptation strategies practised include; moving livestock to other areas where pasture is available, pasture diversification and purchase of hay. Using feed supplements for livestock and grazing control methods such as restricting grazing in some areas and storage of pastures were also preferred. Similarly in an attempt to address water scarcity, the

discussion revealed that trucking water, purchasing of water tanks for both underroof and underground water harvesting had played a great role. Further, formation of WUAs and water committees had played a greater role in water diversification as well as controlling usage at both community and household level.

Other conventional strategies included commercialization of water through provision by private investors, assistance from development expert and extension services, purchase hay and fodder from other areas, drought resistant species, practice grazing control measures such as restrictions to grazing area, use alternative grazing methods including adjustments in grazing patterns, change of human lifestyles and diversification to other livelihoods, increase vegetable or horticultural gardens and diversification outside pastoralism. There were even those loaned water from community WUAs (Table 4.11). The study revealed that conventional adaptation strategies differed significantly from the hypothetical mean (μ=1.403, t = 6.5082, df = 11, p-value <0.0001).

Table 4.11: Summary of conventional adaptation strategies by cluster

Adaptation strategies	**Cluster**	**Proportion**	**Rank**
Store water and hay/fodder	2.785	0.165	1.000
Livestock/herd Diversification	2.155	0.128	0.909
Using the available resources sustainably	2.11	0.125	0.818
Commercialization of water (Private Investors)	1.98	0.118	0.727
Seek Assistance (Expert/ Extension Services)	1.476	0.088	0.636
Purchase hay/fodder from other areas	1.368	0.081	0.545
Drought Resistant Species	1.191	0.071	0.455
Practice grazing control measures (Restrictions)	1.169	0.069	0.364
Use alternative grazing methods (Adjust)	1.061	0.063	0.273
Loan water from community WUAs	0.886	0.053	0.182
Change of Human Lifestyles (Diversification)	0.433	0.026	0.091
Increase vegetable or horticultural Gardens	0.222	0.013	0.000

There was a significant difference between preference for traditional and conventional adaptation strategies (μ_1=1.403, μ_2=1.9751, t = 0.6151, df = 6.688, p-value <0.5588). The study revealed that the three conventional strategies were slightly above the highest

strategy in top five which means that the community in the study area were more inclined to the traditional adaptation strategies. The role of stakeholders was not overlooked. In the case of water and pasture scarcity and its resultant occurrences, the stakeholders were involved in provision of relief food, provision of hay and water trucking for human consumption. Long-term projects established by the stakeholders included drilling of boreholes, construction of dams, construction of hay stores as well as creation of hay reserves. In order to make pastoralism sustainable in the wake of climate variability, the discussions recommended that the government and other stakeholders should extend their role into provision of drought resistant plants, fodder species and livestock. Other recommendations included, ensuring equal distribution of water and pasture resources, increasing provision of rainwater harvesting technologies, integrated water resource management (IWRM) as well as increasing access to remote areas through construction of road networks (Table 4.12). A statistically significant difference was noted in the interventions ($\mu = 1.065$, $t = 3.7317$, $df = 6$, $p = 0.001$).

Table 4.12: Interventions by stakeholders to enhance adaptation strategies

External Interventions	**Cluster**	**Proportion**	**Rank**
Drilling Boreholes by stakeholders	2.429	0.326	1.000
Construction of other water sources	1.777	0.238	0.833
Water Truck are available for purchase	0.914	0.123	0.667
Provision of Gen sets by stakeholders	0.779	0.104	0.500
Safety nets for Restocking are available	0.667	0.089	0.333
Provision of Hays and Fodder is available	0.551	0.074	0.167
Supplementary water provision is available	0.339	0.045	0.000

The challenges and threats attributed to the adaptation included vandalism of water and breakdown of tanks and water equipment. Scarcity of water, and pasture scarcity were blamed by the community to be associated to conflicts over resources and tribal crashes as well as overcrowding, displacement of people, livestock and resource depletion. For these reasons, even with adaptation strategies in place, it was noted that as the human population increases water and pasture scarcity continues also increases. In addition there will be more poverty, hunger, displacement, conflicts, increases psychosocial related illnesses and deaths. The conflict that resulted to Turbi Massacre (claimed 56

lives) was quoted in the FDGs and specifically in Bubisa where notably, the participants echoed the loss of nine lives which was attributed to resource conflicts by the Conflict Early Warning and Response Network (CEWARN, 2005 cited in Temesgen, 2010) instituted by the Intergovernmental Authority on Development (IGAD). The massacre was linked to climate change and resource scarcity (Temesgen, 2010).

The increasing population pressure in these livestock areas are likely to make pastoral economies less self-sufficient especially if access to financial services remain limited. The question of involvement of the local communities in the design and implementation of these projects was raised. It was revealed that major water points were established without considering the traditional migration routes and therefore land degradation in the surrounding areas could have been avoided. These were challenges associated with adaptation strategies (Table 4.13). The study revealed that challenges differed significantly (μ= 0.759, t = 3.5571, df = 11, p-value = 0.0045).

Table 4.13: Summary of challenges by cluster

Challenges in adapting to climate variability	**Cluster**	**Proportion**	**Rank**
Overstocking and overgrazing	2.149	0.236	1.000
Increase in human and animal population	1.935	0.212	0.909
Water sources maintenance & Fuel prices	1.212	0.133	0.818
Unreliable rainfall and poor pasture regeneration	1.106	0.121	0.727
Prolonged droughts are now persistent	1.024	0.112	0.636
Disaster unpreparedness	0.722	0.079	0.545
Inadequate funds to adopt new strategies	0.501	0.055	0.455
Lack of support and goodwill	0.148	0.016	0.364
There is poor planning for resources	0.148	0.016	0.364
There is severe environmental degradation	0.129	0.014	0.182
Change of rainfall patterns	0.035	0.004	0.091
High temperature intensity	0.004	0.000	0.000

The study found that with changes in climate, it would be easier to conclude that almost certainly the local people are supplementing their local adaptation strategies with strategies adopted from other communities or introduced to them by developmental

partners. The study learnt that the community considered long-term intervention options that would enhance pastoralists' resilience at household and community level to address the effects of climate variability. The results included *inter alia* that there is need for afforestation programmes in the rangelands, management of the existing tree species and community education programmes on climate change and variability. The discussion also recommended that there should be continuous management of pasturelands and where possible, adaptation of private land ownership. To enhance the commercial role of pastoralism, a consensus was attained that improved livestock management extension services, livestock size management policies as well as that of improving livestock and livestock products' market should be a national priority. The study revealed that recommended long-term adaptation strategies differed significantly from the hypothetical mean (μ=0.484, t = 4.7113, df = 11, p-value <0.01).

Table 4.14: Summary of proposed long-term adaptation strategies

Proposed long-term adaptation strategies	**Cluster**	**Proportion**	**Rank**
Construction of improved water sources and storage of water in reservoirs	1.321	0.312	1.000
Use of modern livestock production methods, technologies and ICT, paddocking, collective destocking, Improve market for Livestock and Livestock Products	1.083	0.255	0.750
Commercial Production and storage of Fodder including rangeland reforestation	0.898	0.212	0.500
Diversification outside pastoralism, agro-pastoralism, formation of ranches or Fencing of pasture lands to be utilized during severe climatic conditions	0.668	0.158	0.250
Capacity building and educational programs on livestock management, rangeland management and climate change	0.270	0.064	0.000

4.11 Chapter summary

This chapter present and discusses the findings of the study. It found that the community accessed water from various sources some of which are very far. Some respondents remarked that while water had increased, rangelands are receding while others are

decimated by drought (GoK, 2010a; Hurst et al 2012). The results also corresponded with a study piloted to relate climate variability and response strategies among Gadamoji agro-pastoralist communities in Marsabit (Boru & Koske, 2014).

Conclusively, the survey established that water and pasture scarcity is both absolute and relative. Inadequacy of these resources resulting from severe climate is the absolute scarcity while relative scarcity is as a result of trickling effects that are consequential of limiting factors associated with the management of the resource in absolute scarcity. The study revealed that climate variability had resulted to acute water shortage and increased household costs in accessing water and pasture in the study area. In addition, 25% of Africa's population already experience high water scarcity, and it is feared that despite the effects of climate change, some communities are threatened with exceeding the limits of their economically usable land-based water resources before 2025 (IPCC, 2008). This general statement was found to be very relevant to Turbi Division. Sure enough, this is not just a regional concern, it is a concern at the local level.

The study revealed that while water and pasture resource availability was high, accessibility was inhibited by water affordability because in some areas where water was readily available, it was also noted that pasture was receding. The study found that the resilience of the community was dependent on their adaptation strategies which were met with numerous challenges. This resulted to increased vulnerability as the community strived to match towards sustainable pastoralism. According to Koocheki & Gliessman (2005), sustainable pastoralism is dependent on people, livestock and pastures. Therefore, increased vulnerability threatens people to drop off pastoralism. Numerous studies and reports have unambiguously attributed enormous obliterations occasioning from or have an indirect relation to climate change and variability, though the link is still oblique.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In the preceding chapters, literature was reviewed and data collected from the field was analysed and the results discussed. This chapter gives a summary of the main findings, conclusion and the recommendations of this study as well as recommend areas for further research. The study aimed at determining the effects of climate variability and change on water and pasture and the adaptation strategies adopted by the pastoralist communities in Turbi division.

5.2 Summary of the findings

The general findings of the study was that the minimum and maximum temperatures have increased while rainfall amount has reduced in Turbi Division. Interpretation of thirty years meteorological data of the study area reveals that both rainfall and temperature deviated significantly from the long-term mean. A plot of standardised deviates on rainfall data depicted an oscillating trend with two major observable peaks with the year 1997 deviating farthest above the long-term mean and 2000 showing the highest deviation below the long-term mean. These climatic changes have been witnessed by the residents through anomalies in rainfall such as unsystematic patterns, low intensity, poor distributions and unpredictable seasons. Other indicators include continuous disappearance on indigenous plants, drying up of water reservoirs, degradation of pasturelands and reduced productivity of the land. During the rainy season, heavy storms and severe floods were observed to have increased soil erosion and loss of livestock.

This study showed with a high degree of certainty that as a result of an increase in droughts and other extreme weather events in the study area, there has been degradation of the environment and reduced availability of water and pasture resources. Water and pasture scarcity have also been experienced by the community in the study area. Chi square test showed that climate change had a significant impact on water and pasture availability. This has subsequently influenced changes in accessibility and affordability of water and pasture resources in a cyclic manner leading to a change in the utilisation and management practices. Chi square test showed a significant association between

the frequency of watering days at present and fifteen years ago. Climate variability influences water and pasture scarcity. This leads to destruction of natural environment and subsequently causing climate change. Human activities among pastoralist in the study area leads to climate variability and change which further influences these human activities and worsen the effects of water and pasture scarcity.

The study established that people in the study area used both traditional and conventional strategies to adapt to the effects of climate variability. Traditional adaptation strategies were well suited in a situation where climate variability was slightly impacting while water and pasture scarcity were not particularly aggressive. One tailed t-test showed that adaptation strategies differed significantly from the hypothetical mean. The study noted that traditional adaptation strategies were the main pathways through which pastoralists coped with climate variability. However, conventional adaptation strategies were a composite of innovations resulting to the modifications that were not considered by the traditional adaptation strategies.

The traditional adaptation strategies did not take into consideration the challenges posed by the impacts of the recent climate variability. However, conventional adaptation strategies were used as an intervention to address the gaps in traditional strategies. These were further strengthened by support from developmental partners through capacity building and technology transfer. Parametric t-test showed that there was a significant difference between preference for traditional and conventional adaptation strategies. The level to which the traditional and conventional strategies should complement each other was however not established. The study learned that the impacts of climate change will be felt even strongly in the future. In this connection, conventional adaptation strategies used in the study area will not be sufficient to address future water and pasture scarcity. The study showed that the future has many opportunities to pastoral communities amidst water and pasture scarcity but the fact that it is filled with uncertainties cannot be underestimated.

5.3 Policy implications and recommendations

The findings of this study revealed a number of issues both predicted and unforeseen as well as concerns that are likely to horn in if water and pasture scarcity persist. The study sought to determine the effects of climate variability in relation to water and

pasture scarcity in Turbi Division with special attention on availability, accessibility, affordability and utilisation. The region is characterized with poor delivery of social services and absence of basic infrastructure, as well as low literacy levels and land tenure insecurity. There were no observable implementation of climate change adaptation policies in the study area.

The study revealed policy gaps in reducing vulnerability to the future climate variability and change, primarily due to disaster unpreparedness by local communities. Inadequate involvement of local communities in the study area in decision making such as increasing water resources has resulted into severe land degradation. The study found that providing water was a development priority which was unparalleled with planning for pasture resources. Increasing establishment of infrastructure and social services around major centers indirectly influenced sedentary settlements patterns. This can be attributed to continuous degradation of land around those places.

The trends in marginalisation of pastoralists, in education and development especially with regards to engagement in decision and policy making processes concerning water and pasture can be attributed to historical injustices as well as the root cause of pastoral poverty. Attempts to introduce farming in the region were observed to be quite a challenge. Flexibility of the pastoral rangelands of Turbi would not be enhanced by substituting pastoralism with other less flexible systems. Direction of future policy should enhance an economically viable and environmentally sustainable pastoralism.

The viability and sustainability of ranching as an alternative livelihood as proposed by some respondents is questionable. Strengthening of local and customary systems gives communities the power of negotiating for availability, accessibility, affordability and utilization of water and pasture resources. Eliminating water and pasture related conflicts and fear of conflicts in the community contributes to sustainability of pastoralism. In this regard, the study recommends the following approaches:-

1. Pastoralists in Turbi Division have strong traditional institutions and adaptation strategies that had played an increasingly significant role in periods of water and pasture scarcity. The communities and other stakeholders should strengthen these strategies and units to among others; regulate the use of water and pasture resources and other natural resources for conservation, management of risks and

promote collective actions for mutual wellbeing. These traditional strategies are important safety nets and backups in the wake of climate vagaries.

2. Severe climatic conditions are not completely spontaneous. Weather patterns and potential water and pasture scarcities both absolute and relative are foreseeable and early warnings as well as mitigations can be done. The study recommends that the Government of Kenya (GoK), County Government of Marsabit, NGOs, donors and other stakeholders should develop concrete policy frameworks for disaster risk reduction (DRR). Specifically, the communities should embrace disaster preparedness strategies and early warning systems.
3. GoK should pay special attention to the contentious issues of land rights, and land tenure security to the pastoralists' whose mobility and sustainability is dependent on free access to community land. Land tenure insecurity coupled with climate change escalates water and pasture resource scarcity. The local administration should oversee that communities have been adequately consulted in developmental projects.
4. Poor coordination of adaptation strategies leads to increased vulnerability to climate variability. The study therefore, recommends that a coordinated system of adapting to the effects of climate change and variability in water and pasture resources should be prioritized.
5. Finally, the study recommends that the actual problems affecting pastoralist communities should be solved from the root causes. Water and pasture resources and their related scarcity influences social, economic and environmental dynamics of pastoral communities. Therefore, these should be viewed as such and given the attention they deserve.

5.4 Areas for further research

Based on the results, literature review and conclusions derived from this study future researches in the study area and field of study should focus on the following topics:-

1. A study should be carried out to investigate how differently pastoralist women and men respond to climate variations and preference of adaptation strategies between genders. While this study recommended that local institutions should be strengthened, a study is needed on the existing community structures and mechanisms and their roles in adaptations to climate variability.

2. The study recommends the use of GIS and remote sensing in pastoralism. A research should be conducted to model future predictions of climate variability in the study area. A research study should be conducted using satellite data and simulation models to describe spatial distribution of pasture at a farm scale and development of water points.
3. This study recommends that a thorough analysis should be carried out on the extent to which the effects of climate change in water and pasture availability influences both local and cross border migration patterns. Further, studies should also focus on siltation, salinization of boreholes and the effects of water harvesting technologies on hydrology as well as the possibility of solving the long term water crises in the arid lands.
4. Finally, a study on biodiversity loss in the ecosystem should be carried out in order to improve pastoralism and reduce environmental degradation.

5.5 Conclusion

In conclusion, this study established the effects of climate variability on water and pasture and the adaptation strategies adopted by the pastoralist communities in Turbi division, Marsabit County, Kenya. There was a significance variability in temperature and rainfall over the past thirty years (1984 - 2014). Climate variability has largely influenced both traditional and conventional strategiess of coping with water and pasture scarcity. The preference for adaptation strategies differ significantly within and across categories. There are various challenges faced by the communities in an attempt to cope with water and pasture scarcity. The study concludes that climate change had a significant impact on water and pasture availability. Climate variability and change is a grave challenge affecting pastoralism in Turbi Division. Interventions to address water and pasture related issues in the study area such as adaptation of new strategies should also be adopted in other ASALs with similar climatic and environmental setting. Policy considerations should be addressed to unify the accessibility, affordability and utilisation of water and pasture resources in the most sustainable manner. The effects of climate variability should continuously be assessed and more appropriate and timely adaptation strategies be informed across time and space with special focus to the local communities who are the major recipients of water and pasture scarcity as well as ultimate actors in addressing their paroxysms.

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APPENDICES

Appendix 1: Household questionnaire

Please tick the appropriate box that best provides answer to your response

Part 1: Personal details

1) Age and Gender **Gender**

□ 0 – 10	□ 41 – 50	□ Male
□ 10 – 20	□ 51 – 60	□ Female
□ 21 – 30	□ 60 – 90	
□ 31 – 40	□ 90 - 100	

2) Which sub-location do you come from?

□ Turbi……..	□ Bubisa……
□ Burgabo….	□ Shurr……..

3) What is your highest level of formal education?

□ Secondary	□ Adult education	□ Tertiary
□ Primary	□ None attended	

4) Occupation

□ Livestock herder……...	□ Crop farmer……
□ Livestock trader……	□ Others (specify)……..
□ Business person……	……..

5) When did you settle in this area

□ App. 5years ago or less	□ App. 15 years ago
□ App. 10years ago	□ App. 20 years or more

Notes to the Household Questionnaire

1. An introductory letter was attached, signed by the director of field services at the Department of Environmental Education and verified by the area chief.
2. The questionnaires were administered and filled by research assistants with the support and supervision of the researcher, subject to the procedures outlined in chapter 3 above.
3. **Part 2: Resource availability**

6) What are your immediate sources of water?

□ Shallow Wells	□ Borehole

- Dam
- Natural Swamps/Pools
- Under roof Tank
- Rock Catchments
- Seasonal Dam/Pan
- Underground Tank

7) What other such sources are available within your area

- Shallow Wells
- Seasonal Dam/Pan
- Borehole
- Natural Swamps/Pools
- Dam
- Rock Catchments
- Under roof Tank
- Underground Tank

8) How far is the permanent source of water from where you live (approximately)

- ……Meters
- ……. KMs

9) Has water resources in your area increased or decreased since the last one and a half decades?

- Increased
- Decreased

Give reasons for your answer: …… ….

……

10) If you are a livestock farmer, are your animals getting enough pasture and water as they use to get them one and half decades ago?

- Yes……..
- No……..

Give reason for your answer…….

…… ……..

……...

…….……..

Part 3: Resource accessibility

11) Has the accessibility to water change in the last 10 to 15 years or so both for human and animals.

□ Yes……. □ No……..

If yes how,

	In the Past	At the Moment
(i) People in days		
(ii) Sheep and goats in days		
(iii) Cattle in days		
(iv) Camels in days		

12) What distance do you usually cover when getting,

(i) Water for yourself and animals ……..kms

(ii) Pasture for your animals .....…..kms

13) Do you think the water you use is safe for your consumption

□ Yes……. □ No……..

14) Are there instances when one could not get pasture for your livestock?

□ Yes □ No

If yes what do you do during such times

……

……..…….……

…….....……

…….....

Part 4: Resource affordability

15) How do get water for your consumption and livestock

□ For free □ Purchase

In case of (Purchase) above what price do you pay for:-

Description	**Price for each (KES)**
(i) 20 liters	
(ii) A goats or a sheep	
(iii) A cow	
(iv) A camel	
(v) A donkey	

16) Has the above price changed in the last 10 -15 years?

□ Yes □ No

Explain: .....

……..

……..

……..

17) In case of shortage of funds how do you access these resources?

……..

……..

……..

Part 5: Resource utilization

18) These resources are at times plenty and other times scarce. How do you manage them when they are;-

Description	**Scarce**	**Plenty**
Water	……	……
	……	……
	……	……
	……	……
	……	……
Pasture	……	……
	……	……
	……	……
	……	……
	……	……

19) Are there any better ways you may think but can't afford to? .....

……

……

……

Part 6: Climate change

20) Have you ever had or thought of climate variability

□ Yes □ No

21) Do you thing the climate in this area has change from what you use to know or it is the same?

□ It has changed □ It has not changed

22) If your answer is choice (1) what do you think has changed

□ Rainfall □ Sun shine

□ Cloud cover □ Wind pattern

□ Temperature □ Wind Intensity

23) How were the rainfalls seasons by the time of you settling in this area

□ Systematic □ Unsystematic

24) What changes have you observed over time in terms of:-

(i) Rainfall intensity

□ low □ medium □ high

(ii) Rainfall distribution

□ evenly distributed □ sparsely distributed □ spontaneous rainfall

(iii)Rainfall seasons

□ on time □ delayed □ unpredictable

25) What are the recent climatic occurrences in your opinion for the last 10 - 15 years?

□ Severe droughts □ Moderate rainfalls □ Others specify…

□ Floods

26) Did the recurrent climatic occurrences affected water and pasture accessibility in your opinion?

□ Yes…….. □ No……..

If yes how……..

……

27) What adaptation strategies have put in place for example during severe shortage of water and pasture

□ Move to other areas

□ Purchase them from elsewhere

- Plead with well wishers
- Steal them from those who have
- Others specify……
  ……...

28) It's argued that some animals could do well without taking water for quite a long time. In your opinion has this trend changed during the last 10 to 15 years?

- Yes ……..
- No…….

If yes what do you think caused this: .....

29) Do you think it's possible to manage the livestock you have if severe climatic conditions like drought persists?

- Yes …….
- No……

Give reasons for your answer: …….

30) What a the negative implications of above adaptation strategies

- Hunger
- Conflict
- Displacement
- Others (specify)
  ……
  ……

31) What has been the role of stake holders such as government, NGO's and religious organizations in building adaptive capacities?

- Drilling boreholes
- Purchasing gensets
- Purchasing hays
- Water trucking
- Restocking
- Others (specify)

32) Are there any policy measures/framework being adopted in your area by people?

- Livestock diversification
- Drought resistant species
- Others (specify)

33) Of the policy measures you listed above which one is the most effective according to you?…..…… ……
……
..……
…….

Appendix 2: Interview guide for focused group discussions

1) Have you noticed any changes in the climate variables since 1985?

2) Yes [ ] No [ ]

3) If yes, what aspect of temperature and rainfall has changed?

4) What do you consider as the main causes of climate variability?

5) What are the key indicators and impacts of climate variability in Turbi division?

6) What aspect of climate variability (rainfall and temperature changes) pose great challenge to local livelihoods?

7) How has climate variability affected pastoralist livelihoods (mainly in water and pasture accessibility) since 1985?

8) What adjustment has pastoralists in Turbi division made to adapt to effects of climate variability (on water and pasture)?

9) What are the challenges faced by communities in an attempt to cope with water and pasture scarcity?

10) What threats do pastoralists of Turbi division face as a result of climate variability?

11) What is government doing in order to help pastoralist adapt to the impact of changing climate?

12) What should government do in order to make pastoralism sustainable in the advent of changing climate?

13) What livelihood interventions options would enhance pastoralist resilience at household and community level to continued effects of climate variability?

Appendix 3: Interview guide for administrators and NGO workers

1) For how long have you worked in Turbi division?
2) How is the climate of Turbi division?
3) What climate variability have you observed in Turbi division for the last 30 years?
4) According to your opinion/records, how has rainfall and temperature been varying in the region for the last 30 years?
5) To what do you attribute these changes?
6) How has climate variability affected pastoralists access to water and pasture in the region?
7) Do you conduct any research in the field of climate change?
8) What research findings have you come up with to enable pastoralists adapt to climate variability?
9) Are your findings accessible to pastoralists?
10) How has climate variability affected water and pasture accessibility by pastoralists in the region?
11) What are some of the conventional water and pasture stress adaptation strategies practiced by pastoralists in Turbi division?
12) What relevant adaptation strategy should they adopt?
13) What are the challenges faced by communities in an attempt to cope with water and pasture scarcity?
14) What threats do pastoralists of Turbi division face as a result of climate variability?
15) What is government doing in order to help pastoralist adapt to the impact of changing climate change?
16) What should government do in order to make pastoralism sustainable in the advent of changing climate?

Appendix 4: Rainfall data (1984 – 2014)

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
1984	0	0	2.2	180	16.1	1.3	5.6	0.6	13.6	109.7	199.5	16.4
1985	19.3	51.2	99.2	344.7	364.9	19.3	3.4	9.4	3.5	111.9	69.1	54.9
1986	0	0	72.7	224.9	11.8	8	6.3	0	0.7	33.5	125	34.8
1987	45.1	0	11.4	169.3	298	37.2	15.3	16.3	4.2	1.7	73.4	15.1
1988	31.8	3.4	59.9	511.7	14.6	10.8	5.4	9.2	49.3	121.3	140.2	58.1
1989	56.8	38.8	32.3	299.5	76.8	11.7	3.2	3.6	0.3	55.2	201.7	38.2
1990	53.2	133	61.1	302.4	23.3	14.2	0.2	0.3	1	21	109.5	148.5
1991	46.6	0.6	109.9	68.2	15.6	3.9	25.8	20.2	3.7	0.2	27.5	87.6
1992	0.5	46.7		146.2	23	1.5	12.4	3.7	0.7	57	89.6	157.7
1993	104.4		10.5	240.5	243.5	16.8	5.4	1.1	1.2	74.3	59.3	11.3
1994	0	0	8.2	111.7	72.1	0.8	26.6	10.6	2.8	209.1	0.5	70.3
1995	0	76.4	42.8	370.7	120.9	1.4	4.4	18.9	0.8	47.1	138	32.5
1996	8.1	3	46.3	81.4	27	68.5	7.2	3.6	5.8	0.8	68.3	0.1
1997	0	0	42.5	347.1	1.7	3.4	2.2	0	4.9	429.7	472.6	139.7
1998	276.8	40.8	110.1	104	191.1	31.9	14.2	3.1	0	0.8	111.2	9.1
1999	1.2	0	26.8	143.6	9.3	5.6	5	8.5	1.5	10.9	92.1	32.1
2000	8	0.1	0.8	11.4	1	9.2	1.3	0	7.5	8.3	39.5	12.5
2001	32.9	3.3	69.9	181.3	10.7	8.2	7.4	27	0	23.2	193.2	45.6
2002	18.6	3.2	120.4	254.9	53.1	6.1	13	13.2	5	54.6	42.1	310.8
2003	0	0	17.6	263.1	64	12.8	0	17.4	6.8	36.1	219.5	75.7
2005	1	0.8	0.2	176.6	248.4	9.7	0.5	2.9	0.5	110.7	19.5	1.5
2007	8.1	7.2	15.6	101.5	76.6	9.7	24.7	28.2	11.8	108.6	83	6.7
2008	77.4	0	21.8	148.4	6.9	1.8	2.6	12.2	3.2	99.7	288.8	2.9
2009	10.9	19	6.5	26	9.5	4.7	0	0	0	194.6	34.8	84.7
2010	44.7	54	76.8	93.1	36	0	15.8	4.5	2.3	37.7	21.9	4.2
2011	0	32.9	0	81.4	5.3	6.3	0.6	1.5	0	238.9	476.5	9.2
2012	0	1	1.1	269.3	51.1	11		10.6	9.4	157.3	87.8	134.7
2013	44	2.7	347.3	302.7	21.2	2	17.6	6.8				
2014							83					

Source: Kenya Meteorological Department
Used with Permission

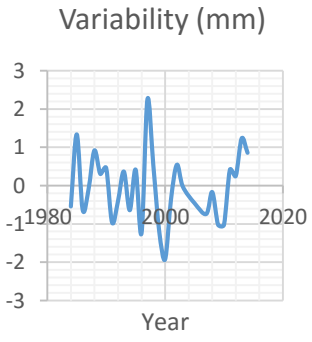
Notes to the Rainfall Data.

1 Blank cells "" represent missing data while zero "0" means no rainfall was recorded in the period. There was no attempt fill in missing data in the study.

2 Missing data included January to December 2004; March 1992; February 1993; Sep to Dec 2013; Jan to Jun 2014; August to December 2014.

3 For the sake of missing data, monthly annual average was used.

4 Inter annual and intra annual variability was calculate using the formulae SDt= (x-ẍ)/s where x is the annual mean; while ẍ and s are the long-term mean (59.9860237) and standard deviation (26.82579954) respectively for a period 1984-2014.



Appendix 5: Minimum temperature data (1984 – 2014)

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
1984	16.6	16.2	16.3	16.8	15.8	14.6	13.7	13.5	14.5	15.5	16.2	16
1985	15.8	16.7	16.6	16.4	15.5	14.2	13.7	13.4	13.9	15	16.3	16.2
1986	15.8	16.5	16.9	16.8	16.4	14.7	13.2	13.4	14.2	15.8	16.5	16.7
1987	16.6	17.2	18	17.8	17.3	16.1	14.7	14.8	15.3	16.5	17.1	17.3
1988	17.7	17.4	17.8	17.4	16.1	15.2	14.4	14.1	14.7	16.1	15.9	15.5
1989	16.4	16.1	16.7	16.4	16.2	14.3	13.6	13.3	14.5	15.7	15.7	16.4
1990	15.1	15.7	16.5	17	16.3	14.2	13.2	13.7	14.2	15.8	16.4	16.6
1991	16.3	17.1	16.9	17	16.9	15	14.3	13.8	14.4	16.3	16.2	16.6
1992	16.8	17.3	17.3	17.8	16.9	15.6	14	13.5	14.3	15.7	16.5	16.9
1993	16.6		16.3	16.7	16.7	15.1	13.3	13.4	13.8	15.1	16.1	16.1
1994	16.6	17.4	16.9	17	16.3	14.8	14	13.9	14.1	15.8	14.9	15.8
1995	16.2	16.1	16.4	16.6	16.1	14.5	14.2	13.5	14.2	15.4	16.2	16.4
1996	16.5	16.9	17.3	17.5	16.8	15.4	13.9	13.7	14.5	15.3	16.6	16.5
1997	16.6	17	16.9	17.4	16.5	15.8	14.7	14.6	15.1	16.2	17	17.5
1998	17.8	18	17.5	18.2	17.2	15.7	14.6	14.5	14.1	15.6	16.2	16.3
1999	16.3	16.2	17.5	16.8	16.2	15.1	14.4	14.4	14.7	15.7	16.6	16.6
2000	16.5	16.6	16.9	17.4	16.4	15	14.2	14.1	14.4	16.4	16.6	16.5
2001	16.7	16.3	16.8	16.3	16.4	14.7	13.5	14	14.5	15.9	16.4	16.6
2002	17.5	16.8	16.6	16.6	16.6	15	14.4	14.1	15.1	16	17	16.6
2003	17	17.4	17.1	17.5	17.2	15.5						17.1
2005	16.7	16.8	17.8	16.8	17.7	15.6	14.5	14.2	14.2	15.5	17.1	16.7
2007	16.5	17.5	17.4	17.9	17.4	15.4	14.9	15.1	15.5	16.2	16.4	16.7
2008	16.4		17.2	16.1	16.2	14.7	14	14.4	15.1	16.1	16.7	14.7
2009	15	15.3	17	17.3	16.9	15.7	14.5	14.5	15.2	16.7	17.4	17.6
2010	17.3	17.9	18.1	18.4	18	16.5	14.8	14.9	15.3	16.9	16.6	
2011	17.3	16.7	17.1	17.5	17.7	16.4	15.2	15.1	15.6	16.8	17.5	17.2
2012	17.1	16.3	17.5	17.5	17.4	15.7		15	15	16.3	17.6	17.6
2013	17.5	17.4	17.5	17.5	16.7	15.2	14.4	14.4				
2014							14.5					

Source: Kenya Meteorological Department
Used with Permission

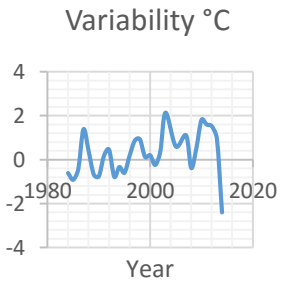
Notes to the Minimum Temperature Data.

1 Blank cells "null" represents missing data while zero "0" means that temperature data was not recorded. There was no attempt fill in missing data.

2 Missing data included Jan to Dec 2004; Feb 1993; Jul to Dec 2003; Feb 2008; Jul 2012; Sep to Dec 2013; Jan to Jun 2014; and Aug to Dec 2014.

3 For the sake of missing data, monthly annual average was used in the study.

4 Inter annual and intra annual variability was calculate using the formulae SDt= (x-ẍ)/s where x is the annual mean; while ẍ and s are the long-term mean (24.736212) and standard deviation (0.860767763) respectively for a period 1984-2014.



Appendix 6: Maximum temperature data (1984 – 2014)

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
1984	27.2	26.9	26.6	26.6	25.6	24.6	23.4	23.7	25.1	24.1	22	23
1985	24.3	26.7	25.4	21.5	22.5	22	23.2	23.6	24.9	24.7	23.9	23.5
1986	25.7	26.8	26.1	24.3	24.7	23.9	23.2	24.1	24.9	25.2	24.1	23.3
1987	25.1	26.8	27.3	25.1	25.3	23.4	23.6	24.2	25.6	26.6	25.7	25.8
1988	26.7	27.6	27.8	25.2	23.7	23.7	23.4	24.2	25.1	25.6	23.1	22.7
1989	24.8	25.3	26.1	23.3	23.3	23	22.8	23.5	25	25.5	23.2	22.9
1990	23.7	25.3	24	23.5	23.7	23.2	22.7	23.6	24.8	25.5	23.8	22.4
1991	23.6	26.4	26.2	25.4	26.1	24.5	22.9	23.8	24.9	26.8	25	24.7
1992	26.1	27.5	27.8	26.1	25.4	25.2	23.7	23.7	25.1	25.5	23.3	22.8
1993	22.8		26.1	25	24.5	23.8	23.1	23.8	24.7	25.5	24.1	24.6
1994	27		27.8	27.3	25.5	25.3	24.4	24.7	25.5	25.2	23.4	23.1
1995	25.5	26.1	25.6	25.6	24.4	23.7	24.2	24.7	25.4	25.7	24.3	23.8
1996	25.6	26.7	26.3	26.5	26.5	24	23.4	24.4	25.1	25.5	24.1	25.2
1997	26.4	28.1	26.6	24.3	23.7	24.3	23.8	24.5	25.3	22.8	22.6	23
1998	23.3	24.9	24.8	25.4	24.6	23.8	22.8	23.8	25.1	26.3	23.7	24.3
1999	26	27	26.7	25.8	24.6	24.3	23.8	24.4	25.4	25.5	23.9	22.4
2000	24.8	27.1	27.2	26.9	26.1	24.3	23.5	24.2	24.9	26	25	25.8
2001	26.4	26.3	27.2	23.8	25.1	23.9	23.1	23.9	25.1	25.6	22.9	22.8
2002	25.5	26.9	26.2	23.8	23.7	23.6	23.7	24.1	25.2	25.1	25.1	23.7
2003	25	27	27.2	26.2	24.2	24.1						23.5
2005	26.3	26.8	28	26.2	25.1	23.5	23.1	24	25.1	25.7	24.1	25.4
2007	24.6					0			26.3	25	23.1	24.4
2008	24.6		26.7	24.3	24.6	23.8	23.5	24.5	26.1	25.4	24	24.5
2009	25.4	26.3	27.1	27.1	26.5	25.6	24.3	24.5	25.6	24.5	24.9	24.5
2010	25.4	27.1	25.6	26	26.4	25.4	23.9	24.2	25.3	25.8	25.2	
2011	26.5	27.4	27.8	26.6	26.7	25.3	24.9	24.9	25.8	24.6	23.1	24.7
2012	26.8	27.4	27.2	26	25.3	24.4		25.2	26	25.4	24.3	23.1
2013	26.5	27.3	26.4	23.7	24.4	22.8	23	23.7				
2014							23.9					

Source: Kenya Meteorological Department
Used with Permission

Notes to the Maximum Temperature Data.

1 Blank cells "null" represents missing data while zero "0" means that temperature data was not recorded. There was no attempt fill in missing data.

2 Missing data: Jan-Dec 2004; Feb 1993; Feb 1994; Jul-Nov 2003; Feb-Aug 2007; Dec 2010; Jul 2012; Sep-Dec 2013; Jan-Jun 2014; Aug-Dec 2014.

3 For the sake of missing data, annual monthly average was used.

4 Inter annual and intra annual variability was calculate using the formulae SDt= (x-ẍ)/s where x is the annual mean; while ẍ and s are the long-term mean (15.810042) and standard deviation (0.54419773) respectively for a period 1984-2014.