

**ASSESSING SUSTAINABILITY OF PASTORALISM UNDER A CHANGING
CLIMATE IN KAJIADO COUNTY, KENYA**

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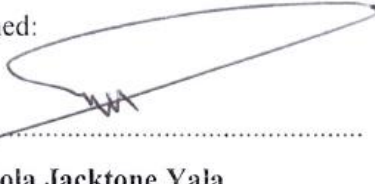
**THESIS REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE
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PLAGIARISM STATEMENT

I declare that this Thesis is my original work and has not been submitted to any University for research. All references cited in the text have been properly acknowledged and referenced in accordance with University of Nairobi's requirements.

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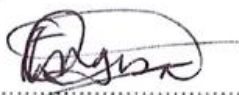
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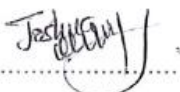
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DEDICATION

This Thesis is dedicated to my late father, Naftal Achola, my wife Dr (Mrs) Alice Yalla and my children Gordon, David, George and Brian. I thank my wife and children for their support and encouragement. God bless you abundantly.

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ABSTRACT

The study was conducted in Kajiado County to assess the sustainability of pastoralism under a changing climate. The specific objectives were to analyse trends in climate and livestock disease occurrence in Kajiado County, identify impacts and challenges facing pastoralism as a production system, opportunities and adaptation measures applied by Maasai pastoralists to mitigate impacts of climate change and variability in Kajiado County. The primary data was collected through focus group discussions, key informant interviews and expert opinion interviews while the secondary data was from the Kenya Meteorological Services and the Department of Veterinary Services in Kajiado. Quantitative data on rainfall, temperature and livestock disease incidence and interventions were analysed through descriptive and inferential statistics measures while qualitative data on rainfall, temperature and livestock disease incidence and interventions were analysed through content analysis. Data on adaptation strategies and livestock disease prevalence was analysed through analysis of the scores using Kruskal-Wallis h test while the data on challenges and opportunities were analyzed through thematic analysis. The findings indicated that there was no evidence to show that annual temperature and rainfall figures had changed significantly between 1970 to 2015 ($P > 0.05$) but there was variability in both temperature and rainfall figures with the coefficient of variation increasing from 21.6% (1970 to 1993) to 32.02% (1994 to 2015) for the rainfall and the coefficient of variation for temperature increasing from 2.6% (1970 to 1993) to 4.04% (1994 to 2015). Diseases that significantly affected livestock included east coast fever, foot and mouth disease and anthrax and black quarter, peste des petits ruminants and contagious caprine pleuropneumonia ($Z > 1.96$). The findings further showed that the impacts of climate change and variability on the Maasai pastoralist community were characterised by increased incidences of livestock diseases, massive livestock deaths and the challenges affecting pastoralist communities included unavailability of veterinary vaccines and drugs, high cost of vaccines and drugs, among others. The adaptation measure that was frequently implemented by pastoralist during flooding was livestock vaccination and mass treatment of sick animals ($Z > 1.96$) while while the most frequently implemented adaptation measures during drought periods included migration ($Z=1.51$) and livestock vaccination and treatment of sick livestock ($Z=1.08$). The study has shown that there is climate variability that is significantly impacting on sources of livelihood for the pastoralists who in turn are implementing several adaptation measures. It recommends formulation and implementation of appropriate plans and policies that are focussed on supporting resilience of the vulnerable pastoral community in Kajiado County.

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ABBREVIATIONS AND ACRONYMS

| | |
|----------------|--|
| ANOVA | Analysis of Variance |
| ASALs | Arid and Semi-Arid Lands |
| CBEWS | Community Based Early System |
| CBPP | Contagious Bovine Pleuropneumonia |
| CCPP | Contagious Caprine Pleuropneumonia |
| CV | Coefficient of Variation |
| ECF | East Coast fever |
| EO | Expert Opinion |
| FAO | Food and Agriculture Organization of the United Nations |
| FBO | Faith Based Organizations |
| FGD | Focus Group Discussion |
| FMD | Foot and Mouth Disease |
| GDP | Gross Domestic Product |
| IFAD | International Fund for Agricultural Development |
| IGAD | Intergovernmental Authority on Development |
| IPCC | Intergovernmental Panel on Climate Change |
| IRG | International Resources Group |
| KCIDP | Kajiado County Integrated Development Plan |
| KMS | Kenya Meteorological Stations |
| KFSSG | Kenya Food Security Steering Group |
| KII | Key Informant Interview |
| KNBS | Kenya National Bureau of Statistics |
| MDG | Millennium Development Goal |
| NACOSTI | National Commission for Science, Technology and Innovation |
| NDMA | National Drought Management Authority |
| NGO | Non-Governmental Organization |
| PAR | Participatory Action Approach |
| PLA | Participatory Learning Action |
| PRA | Participatory Rural Appraisal |
| PPR | Peste des Petits Ruminants |
| RPLRP | Regional Pastoral Livelihoods Resilience Project |
| RVF | Rift Valley Fever |
| SPSS | Statistical Package for Social Sciences |

| | |
|---------------|---|
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USAID | United States Agency for International Development |
| WEF | World Economic Forum |
| WSPA | World Society for the Protection of Animals |

DEFINITION OF KEY TERMS

Atmosphere refers to the blanket of air that surrounds the earth and that moves both horizontally and vertically thus causing variations in weather and climate.

Climate is the average weather for a given place or a region and it defines typical weather conditions for a given area based on long-term averages usually over a number of years

Climate change refers to any change in climate over a period of time, usually over decades or centuries and it is usually due to either natural variability or anthropogenic forces.

Climate change adaptation, according to IPCC (2007), refers to measures and initiatives aimed at reducing the vulnerability of natural and human systems against actual or expected climate change effects or adjustment in natural or human systems in response to actual or expected climate stimuli or their effects

Climate trend is a change in climate which is apparent across a wide range of observations

Climate variability refers to the variation in a climatic parameter of a region from its long-term mean and it may result from natural internal processes within the climate system or from variations in natural or anthropogenic external forces

Climate variables refer to group of linked variables that contributes to the characterization of climate and they include rainfall or precipitation, temperature, wind and pressure.

Coefficient of variation (CV) is defined as the ratio of the standard deviation to the mean. It shows the extent of variability in relation to the mean of the population.

Pastoralism is a complex livelihood system seeking to maintain an optimal balance between pastures, livestock and people in uncertain and variable environments, according to Okoti *et al.* 2014) and Catley *et al.* 2016 described pastoralism as a livelihood in which at least 50% of a household's food and income is derived from livestock and it is characterized by the seasonal movement of livestock to access grazing pastures and water.

Standard deviation is a measure that is used to quantify the amount of variation or dispersion of a set of data values. A low standard deviation indicates that the data points tend to be close to the mean while a high standard deviation indicates that the data points are spread out over a wider range of values.

Sustainability is the ability of a situation or environment to be maintained at a certain rate or level.

Vulnerability is the degree to which people, property, systems economic, environmental or social activity is susceptible to harm, degradation, or destruction on being exposed to a hostile agent or factor.

Weather is the day to day state of the atmosphere and includes short-term (hours to few weeks) variations in precipitation, humidity, cloudiness, visibility or wind.

CHAPTER ONE

INTRODUCTION

1.1 The Study Background

According to Nasir *et al.* 2018, overall changes on the earth's climate have resulted from changes in global climate and this has caused shifts on average weather patterns that have been observed during last 30 years or more. IPCC (2013) reported that global temperature had increased averagely by 0.85°C for the period between 1800 and 2012 as compared to the period between 1961 and 1990 and that for the last 100 years (between 1906 and 2005); there has been an increment on global temperature, averagely by 0.74 °C ± 0.18 °C. Pastoral production systems are facing several challenges arising from climate change that is currently being experienced globally as the systems depend on climate-dependent natural resources such as pasture and water.

Pastoralists view global climatic changes as erratic rainfall, reduced rainfall amounts, increase in temperature levels and frequent and prolonged periods of drought. Increase in climate variability would also lead to decrease in the number of animals kept by individual pastoralists as a result of livestock deaths and poor performance in reproduction thus affecting food security and compromising dependence on livestock and their products. Conflicts over livestock assets as a result of environmental changes and socioeconomic factors, such as increase in human population and change in land use system (for human settlement, agricultural use or industrial development) would disrupt pastoral activities leading to marginalization. These are some of the effects of global environmental changes in pastoral areas. IPCC (2013) and IPCC ((2014) described climate change as a human induced (anthropogenic) where the human activities cause production of greenhouse gases that are released into the environment thus causing alterations in climate variables over a period of time with the end result being climate change.

Climate change has raised challenges for the pastoral communities in Africa and other areas where pastoral systems are being practised. Climatic shocks have led to livestock, human and financial loses (Oxfam, 2012). The 2010/2011 drought that was considered the worst in the past 60 years in the Northern part of Africa saw over 13 million people affected by severe humanitarian and food crisis with an estimated 50,000 to 100,000 fatalities (IGAD, 2012). Rise in temperatures, decrease in rainfalls and frequent droughts have become common climatic features in most ASALs of Africa. These fluctuations are putting pressure on the pastoral production systems since the pastoralists have limited resources to rely on with the

advent of climatic changes. Pastoralists have used indigenous knowledge to guide them in the protection and exploitation of the frequently changing dry weather conditions to support their livelihood systems even before the advent of climate change (Mohammed *et al.* 2012). What is now new is the extent to which the exposure factors such as prolonged droughts and extremely high temperatures are exerting an ever-increasing pressure on their livelihoods which is dependent on livestock (Maereg *et al.* 2013).

Pastoralism as livelihood system is a system where the pastoralists seek to maintain a balance among themselves, pasture and livestock in an environment that is variable and uncertain (Okoti *et al.* 2014). Catley *et al.* 2016, further described pastoralism as system of livelihood where household's food and income of at least 50% of a given population is got from livestock production and that the livestock are seasonally moved when searching for water and pasture especially during drought periods. As an extensive livestock production system in rangelands, pastoralism is characterized by different features, but the main features that define pastoralism in rangelands are livestock movement in search of pasture during drought and communal natural resource management (ASAL Policy, 2015). The animals kept under pastoral production systems depend on pastures that grow naturally for grazing with quantity and quality of pastures and water being determined by rainfall. Most of the animals kept are indigenous breeds and the animals are kept as economic assets, for social status, cultural and spiritual reasons. Natural pastures and water are considered common properties with accessibility limited to flexibly negotiated arrangements through community leaders.

The fact that livestock depends on pasture and water and that both water and pasture are climate-dependant makes livestock and climate to be closely related. The rainfall pattern and availability determine how water and pasture would be spatially distributed and available ((Iqbal, 2013 and Aklilu *et al.* 2013). Rainfall patterns and ranges that occur in temperatures affect pasture availability in grazing areas, quality of pasture and occurrence of pests and diseases, according to Coffey (2008). Diseases of livestock that are sensitive to climate variability and change include Rift Valley fever, Blue Tongue, Lumpy Skin Disease, Anthrax, Foot and Mouth Disease (FMD) among others. Increase in livestock disease incidences would result on livestock deaths, poor livestock performance and collapse of livestock markets leading to increment on vulnerability of the pastoralists and uncertainty in sustainable pastoralism. The pasture production is affected by both the rainfall pattern and temperature ranges by the fact that production timing is important since alteration in precipitation patterns and the peak of the rainfall period would determine when the pasture would germinate and

mature up. The short rainy periods might result in long periods of poor quality and inadequate pasture while an increment on dry seasons that are frequent and extreme would make availability of pasture to be uncertain. The negative impact of droughts arising from the climatic changes has evidently been seen among the pastoralists through loss of their livestock and increase in number of people receiving food aid ((Nori and Davies, 2007).

The traditionally known bi-modal rainfall pattern in Kajiado has been seen to be changing. This change has been observed in unpredictable and unreliable rainfall patterns (CIDP, 2013). The devastating effects on people's livelihoods arising from this unpredictability and unreliability was seen during the 2006/2007 and 2008/2009 droughts where there were reported livestock deaths in excess of 70% in most parts of the County according to CIDP (2013). Climate change and variability is therefore extending a difficult situation for the Kajiado pastoral community beyond previous adaptation capacities thus calling for employment of other adaptation strategies to mitigate against climate variability and change.

Climatic changes and pastoralism have emerged as complex research problems that require broader approach such as multidisciplinary approach. The study used transdisciplinary research approach focusing on the complex problems of pastoralism and climate change to collect a host of views. These problems required creative solutions, stakeholder involvement and use of social science and environment. The survival of pastoralism under the changing climate would depend on implementation of policies that could secure and strengthen it as a core user of the ASALs and at the same time creating alternative livelihood opportunities for the pastoralists.

1.2 Problem Statement

Pastoralism is a form of livestock production system where livestock is reared for provision of food, financial capital and description of wealth among the pastoralist communities, depends on the natural resources whose quality and quantity also depend on climate. Climate change therefore has direct and indirect effect on pastoralism and by extension, livestock production. Some of the direct impacts of climatic changes on pastoralism and production of livestock include increment in frequent and extreme weather conditions such as frequent floods and droughts, production loss as a result of extremely high temperatures and increase or decrease in water that is available for livestock and pasture productivity. The indirect impacts could include emergence of new diseases and increment in livestock disease

incidences as a result of changes in host-pathogen interactions and quality and quantity of pasture.

Increase in frequency of droughts, decrease in water sources and encroachment onto land meant for grazing are increasingly becoming a threat to pastoralism (Catley *et al.* 2012). The majority of the population in Kajiado depend on pastoralism, which is a traditional livestock-based system, as a livelihood source. With the variability in rainfall and temperature due to climatic changes, the traditional pastoral production system in Kajiado is facing challenges. The changing climatic conditions characterized by prolonged droughts, floods, low pasture production and drying up of water sources are impacting on pastoralism/livestock production thus creating new challenges for the traditional livestock-based livelihood in Kajiado County. Emerging land tenure system which is now encouraging individual and private land ownership has further aggravated the challenges occasioned by climate change and variability.

1.3 Research Questions

Based on the problem, the study identified research questions as follows:

- i) Are there trends in climate and livestock disease occurrence in Kajiado County?
- ii) Are there challenges that are associated with climate variability and change and opportunities that could be implemented to sustain pastoralism in Kajiado County?
- iii) Which are the adaptation strategies being applied to mitigate effects of climate variability and change by the Maasai pastoralists in the County of Kajiado?

1.4 Research Objectives

The overall objective was to assess sustainability of pastoralism by the pastoralists in Kajiado County under the changing climate. Specific objectives were to:

- i) Analyse trends in climate and livestock disease occurrence in Kajiado County
- ii) Identify challenges that are associated with climate variability and change and opportunities for implementation for sustainability of pastoralism in Kajiado County
- iii) Identify and document current response strategies applied by pastoralists to mitigate climate variability and change effects in Kajiado County

1.5 Justification of the Study

The frequent and prolonged drought arising from erratic rainfall is causing the water sources to dry up, low pasture productivity and livestock deaths in Kajiado. This is raising concern on the Maasai pastoral livelihood which is dependent on pastoralism in the County. The observed climatic changes are presenting challenges to pastoralism as a production system in the County. To address the challenges facing the pastoralists due to climate variability and change, scientific data that supports implementation of appropriate policies and strategies need to be generated. The study was justified by the fact that the findings could be useful on advising the policy makers on policies and plans on the development of community-sensitive climate change response strategies that could support resilience of the pastoralists within Kajiado County and similar set ups of pastoral production systems in other areas or regions.

1.6 Significance of the Study

The increasing frequency of extreme weather conditions that include floods and frequent droughts that are resulting from climate variability and change are a threat to food security and livelihood of pastoralists that depend on pastoralism as the main source of livelihood. The dwindling climate-dependent natural resources (water, pasture) that support livestock production and by extension pastoralism is making the future of pastoralism in Kajiado County to be uncertain. This has created a need for understanding how pastoralists' vulnerability to climate variability and change could be reduced and their adaptive capacity increased through identification and implementation of appropriate adaptation strategies and plans. This study will identify resources, tools and approaches that would support pastoralism in the County. Identified plans and strategies could be able to assist in future action and planning for climate change and variability purposely to safeguard the pastoralists' well-being, food security and livelihoods in Kajiado County.

1.7 Scope of the Research

The study took place in Kajiado County. The County is classified as semi-arid land. Semi-arid lands practice mixture of economic activities that could include agriculture, agro pastoralism, pastoralism and tourism while arid lands predominantly practice pastoralism. Semi-arid land of Kajiado has four livelihood zones that include mixed farming, marginal mixed farming, agro pastoral and pastoral distributed within the County's five sub-counties. Therefore, although the study was undertaken in all the five sub counties but more emphasis was put on the sub counties with more pastoral activities. These included Kajiado Central,

West, East and South of the County. The study assessed the sustainability of pastoralism under a changing climate through analysis of trend in climate and disease incidence, identification of impacts of climate change and variability, adaptation strategies being applied to address the impacts and opportunities that could be implemented for sustainability of pastoralism in Kajiado County. In looking for the solution to the complex societal problems and situations within Kajiado resulting from climate variability and change, this study used transdisciplinary research approach. Transdisciplinary approach which is a combination of participatory and conventional research methods was meant to democratize knowledge and accommodate different views from respondents, experts and researchers with aim of solving the complex problems on pastoralism associated with climate variability and change within Kajiado County.

CHAPTER TWO

LITERATURE REVIEW

2.1 Transdisciplinary Research Approach

Transdisciplinary approach emerged in the 1990s when the need for solution to address urgent, new, highly complex and global issues arose. The need for new kind of knowledge that is different from the one generated from one discipline or temporary alliances among disciplines has pushed for a move towards specializations in research approaches. This is because the society's problems are becoming too complex to be addressed through one research approach. Climate change and sustainability are emerging as complex global issues and are extending into many areas that concerned science, technology, policy, arts, education and society. In an attempts to solve complex societal problems and situations, there has been a growing trend to integrate various disciplinary approaches to address these problems and situations. Transdisciplinarity has been seen as the answer to solve the complex research problems. For over two decades now, efforts have been made by both national and international researchers to make social and health scientists work together with the aim of addressing health issues that have been considered complex. As a result of this, disciplinary research has emerged (Rosenfield and Kessel, 2008). Transdisciplinary research has therefore emerged as a collaborative research approach where information can be exchanged, various research disciplines can be integrated, different research approaches can be altered and resources shared out with the aim of achieving scientifically a common goal.

With transdisciplinary research approach, epistemologies, theories, methods, different perspectives and frameworks could be integrated to enable a scientific research get a deeper understanding of phenomenon which is social in nature (Schaefer-Mcdaniel and Scott, 2011). Transdisciplinary research is a research approach that cuts across various disciplinary boundaries thus creating a holistic research approach that focuses on problems which cross two or more disciplines. In addition to being additive, it has created room for interrogation across disciplines, generation of new knowledge, learning and better understanding. The participatory approach has enabled the integration of all stakeholders and disciplines for achievement of desired outcomes that are characterized by common objectives, paradigms and approaches. The use of transdisciplinarity as a research methodology has enabled researchers to investigate research issues from different views and perspectives. This has brought deeper collaboration among individuals that possess expertise in different fields giving these individuals an opportunity to exchange ideas among various disciplines, expose

any research assumptions and address conflicts within research issues (Schaefer-Mcdaniel and Scott, 2011).

Transdisciplinary research approach focuses on complex problems that might require creative solutions, stakeholder involvement and use of social science (Bernstein, 2015). Pastoral production systems have been shaped and driven by correlated and interconnected ecological, social and economic processes, requiring transdisciplinary approach to transcend the traditional nature/culture divide (Zinsstag *et al.* 2016). Changes in climate and pastoralism have been recognized as complex since both are affected by physical, political, social, economic, cultural and psychological environments. To bridge a gap in the contributions of the academics, professionals and community practices for sustainable environment, community members, practitioners, environmentalists and researchers have a big role to play (Ranjan, 2017). Transdisciplinary research is increasingly becoming an integral part of an effective research activity. While translation of knowledge is regarded as a solution that could improve benefits and relevance of any research problem, the influence on translation of knowledge in transdisciplinary research has not been fully utilized limiting the potential impact of Transdisciplinarity (Mandy *et al.* 2018).

Transdisciplinary approach as a combination of participatory and conventional research methods democratize knowledge and accommodate different views from all research participants including respondents, experts and researchers themselves to enable understanding of the complex systems. The demand for multiple disciplinary researches that would be able to address the emerging complex societal problems that cannot be addressed by a single research discipline has evolved. The complex world problems and issues that could not be addressed through a single research discipline but require broader research approach can now be explicitly addressed through multiple disciplinary approaches. With the realization that one discipline cannot address adequately, the complex problems of pastoralism and climatic changes, transdisciplinary research approach has been seen as an approach that can integrate knowledge at the level of problem, research and solution.

According to Hernandez-Aguilar (2018), the application of transdisciplinary methodology in the use of agricultural experimentation allowed for the development and selection of solutions based on quantitative scientific evidence. Transdisciplinary research approach requires two different types of knowledge integration: Vertical and horizontal knowledge integration. Horizontal is as integration across knowledge perspectives including disciplines or sectors. It can facilitate a holistic and socio-ecological understanding of both climate change as an

emerging problem and pastoralism. Vertical would enable integration amongst different knowledge providers and users. Such perspectives are from both academic and non-academic, stakeholders (local communities), Non-Governmental Organizations among others.

2.2 Pastoralism

Pastoralism is a complex livelihood system that is seeking to maintain a balance among livestock, pasture and human beings in uncertain and variable environment (Okoti, *et al.* 2014). Catley *et al.* 2016, on the hand described pastoralism as a livelihood system where household's food and income of at least 50% of a given population is got from livestock production and that the livestock are seasonally moved when searching for water and pasture especially during drought periods. Culturally pastoralists have developed beliefs, practices and knowledge that guide them in using and managing their surrounding sustainably. Psychological environment for the pastoralists under climate change and variability revolves around survival of their large number of herds that they have to migrate with during drought in search of pasture and water. Apart from the cultural and psychological environments, pastoralism also has other ecological and sociocultural issues that need to be addressed under the changing climate (Djordjević-Milošević *et al.* 2020). Within the Sub-Saharan regions of Africa, there is estimated human population of 386 million comprising of pastoral communities whose livelihoods are supported by the natural resources that are sensitive to climate (IPCC 2015; Adhikari *et al.* 2015; Thornton *et al.* 2007; Conway 2009).

Davies *et al.* 2010, described pastoralism as a livelihood that is based on livestock production and that it has recognizable values, beliefs, traditional knowledge and sociocultural norms that revolve around livestock keeping. Pastoralism heavily depends on climatic conditions for pasture and water for their livestock and therefore, it very vulnerable to climatic changes (Bobadoye *et al.* 2016). Pastoralism uses extensive grazing on rangelands to support livestock production systems in ASALs making livestock rearing to be the major livelihood source for the majority of the pastoralist community (African Union, 2010; Thornton and Gerber, 2010; Notenbaert *et al.* 2007) but the communal land tenure transformation currently going on in many of the ASALs is becoming a limitation to the use of extensive grazing on rangelands by pastoralists. Therefore, for sustainability of pastoralism, there is need to put in place sustainable land management initiatives. Pastoralists' livelihoods are extensively evolving due climatic changes in ASALs (Thornton and Gerber (2010); Notenbaert *et al.* 2007). The evolution which has been occurring over generations has been as a result of marked variability in rainfall and temperature. According to African Union (2010), the flexibility and mobility

in pastoralism still has the potential to generate economic growth, manage environment, promote sustainable development and reduce poverty in the final end. Zinsstag *et al.* 2016 reported that for any future development of pastoral areas, there is need for engagement of all stakeholders and utilization of the available local knowledge systems that is possessed by the pastoralists.

The social and ecological processes in pastoral system is usually discontinuous and dynamic with some years having adequate rainfall while some have very little rainfall accompanied by occurrence of other disasters such floods and extreme droughts. Reflection on the sustainability of pastoralism should therefore consider the contribution of all key stakeholders and especially pastoralists themselves; combining academic thinking with local knowledge systems in participatory processes as ascertained by Hirsch *et al.* 2008. Climate change and variability has piled pressure on pastoral production systems, forcing the pastoralists to identify appropriate adoption technologies that could address the agro-ecological conditions created by climate change and variability with the aim of developing strategies to enhance food security and sustain their livelihood (Kirimi *et al.* 2013). Loss of livestock as assets by the pastoralists could lead to the collapse of pastoral economy with the resultant serious effects on livelihood of pastoralists and long standing poverty (IFAD, 2009). Despite important contribution by pastoralism to nutrition and food security in Africa and other parts of the world, pastoralism is still facing several challenges with climate change and variability being just another added challenge to the pastoralists.

Catley *et al.* 2012 noted that increase in frequency of droughts, decrease in water sources and encroachment onto land meant for grazing for farming and other commercial ventures are increasingly becoming a threat to pastoralism and by extension, pastoralists' lifestyle. Case studies and systematic reviews of pastoral systems point out their substantial economic contribution and irreplaceable role in the ecologically sustainable use of the grasslands for food production and sustainable development (Hatfield and Davies, 2006). In Africa region, pastoralism is practiced in Kenya, Ethiopia, Somalia, Sudan, Eritrea, Djibouti, Uganda and South Sudan. These countries which are under the umbrella body IGAD are characterized as ASALs. Characteristically, these counties receive annual rainfall 600mm and below and are prone to frequently occurring droughts. The inhabitants of IGAD region are agro pastoral and pastoral communities who largely depend on livestock rearing for their livelihoods (FAO and IGAD, 2019). According to Catley *et al.* 2016, pastoralists found within these countries occupy ASALs that have spatial and temporal variability in rainfall. Although the pastoralists living

within these areas had developed successfully tested adaptive strategies, through their traditional knowledge, that have been enabling them to manage their resources to mitigate against environmental shocks that are associated with arid and semi-arid lands, drought impacts have been exacerbated by climatic changes, ecological degradation, insecurity and population growth in the ASALs (IGAD and FAO, 2019). Study conducted through Omollo *et al.* 2018 showed that pastoral communities with large herds of cattle and who have no preserved pasture would keep moving with their livestock to search for pasture and water especially during drought since pasture greatly affects productivity in livestock. Ingrid *et al.* 2009 noted that pastoralism as a way of livelihood is undergoing drastic changes due to challenges arising from the impacts of climatic changes. Vulnerability of pastoralism to changes in climate is increasingly becoming higher with loss of track on coping mechanisms to recurrent droughts and this might lead to discarding pastoral life altogether.

Although pastoralists are currently facing challenges such as loss of grazing land as a result of other activities such as industrialization and human settlement, increase in human population, weak governance and climatic changes, sustaining pastoralism without interfering with the environment is also another big challenge they have to contend with (Ofoegbu *et al.* 2018). Overexploitation of land resources through cutting of trees, desertification caused by climatic changes, human population increase and land degradation are worsening the situation for pastoralism as they pose additional threats to the already threatened pastoral production system (UNDP, 2006). It has also been noted that pastoralists are largely found within the Least Developed Countries and due to limited resources within these countries, the pastoralists have limitation in adapting to or mitigating against climatic changes as the pastoralists highly depend on the environment for their subsistence (UNDP, 2007; UN, 2007). The developing countries are likely to suffer more as change in climate predictably may have considerable effect on their sustainable development. Although pastoralism has been regarded as an old mode of production of livestock in some parts of eastern and northern Africa with little or no developmental agenda, the projected increase in frequency and severity of drought through climatic changes, is making pastoralism to increasingly become a major feature developmental agenda for Africa as a continent (Kelemework, 2012). Pastoralism is becoming a victim of climate change manifestations further raising the question of whether pastoralism would be sustainable under the changing climate despite its major contribution to the pastoral and national economy.

Recent researches have pointed out that causes of failure in pastoral livelihoods are arising from social problems and that changing climate is just an exogenous trigger (Pekka *et al.* 2011). The unfavourable development policies in ASALs, the role of marketing structure, non-climate and climate transformations and varying adaptation strategies have left the pastoralists with limited options thus increasing their vulnerability (Morton, *et al.* 2016). More than 60% of the inhabitants in the ASALs live in conditions of extreme poverty depending on less than one US dollar per day with the major reason for this extreme level of poverty being environmental degradation and climate shocks (Heltberg *et al.* 2009).

Although (ASALs) are characterized by high incidence of poverty, they are endowed with immense natural resources and livestock. In Kenya, livestock contributes 47% to agricultural GDP and 12% to GDP with most of the livestock production activities being in the ASALs (Kabubo-Mariara, 2009). Of the total land mass in Kenya, 82% of the land is classified as ASALs with human population of about 25% and slightly over 50% of the Country's total livestock population livestock found within the ASALs. Kenya's ASAL pastoral economy contributes to 95 % of family income and livelihood security and 90 % of employment opportunities despite the fact that the ASALs are exposed and sensitive to the frequently experienced prolonged droughts (ASAL Policy, 2015). Kirimi *et al.*, 2013 stated that livestock is accounting for most of the family income and provides employment to most of the Kenyan population in ASALs but pastoralists have continued being poor and food insecure.

According to ASAL Policy (2015), national priorities, policy and institutional arrangements and governance systems have not given precedence to livestock production and the climate change is worsening the livestock productivity in the ASALs, posing a major threat to both pastoralism and development. Opinions now divided over the future of pastoralism in Kenya. Some experts consider pastoralism as unexploited economy with great potential under the changing climate while other experts think that pastoralism as a system is an adaptation strategy to climatic changes that can suitably handle the threat from climate variability and climate (Davies and Nori, 2008).

Constrained mobility in pastoral production systems occasioned by encroaching sedentary farming systems and emerging land tenure systems which encourage individual and private ownership of land further is increasingly constraining livestock production and pastoral systems (Silvestri *et al.* (2012)). Nori and Davies (2007) observed that pastoralism is sensitive to growth in human population since as compared to crop growing areas, raising productivity in the pastoral producing areas would get limited when human population increases hence

tending more to resource-degrading. The climate change effects are resulting in low livestock productivity raising further concern over sustainability of pastoral production systems in ASALs in Africa (Ayantunde *et al.* 2011).

Semi-arid and high-altitude pastoral ecosystem of Kajiado is supportive to livestock production systems and not to crop production for human nutrition. Livestock production in the County is characterized by seasonal movements to various locations both within the County and outside the County especially during drought in search of pasture and water (CIDP, 2013). Therefore, land in Kajiado is majorly used for livestock production activities since livestock is able to adapt to the variable environmental conditions. Livestock production system is known to play key role in the pastoralists' livelihoods as livestock provides food security and economic base for the pastoralists in the County. Dependency of livestock production on the availability of rain-fed natural resources in the County makes it susceptible to changing climatic conditions.

Livestock production supports livelihood of the majority the pastoral community in the County but there is pastoral resilience that is demonstrating the pastoral production system suitability in the semi-arid environment of Kajiado County. With the changing climatic conditions and land subdivisions, the environment in Kajiado is now characterized by uneven distribution of grazing land, high temperature, variable rainfall and shrinking water points making pastoralism to be under threat. The current change in land tenure is presenting a big challenge to pastoralism as a production system in Kajiado County. Subdivision and sale of land meant for grazing is reducing the practice of pastoralism as production system since the land is meant to produce pasture which is crucial in livestock productivity. Therefore, there is need to put in place some land use plans that can be used in regulating subdivision and use of land to avoid future challenges for pastoralism as a livelihood source for the majority of the populace in Kajiado County (Nkedianye *et al.* 2020). There are various opportunities available for the pastoralist in Kajiado but these opportunities depend on the livestock that are owned as assets coupled with socio-economic and environmental challenges that hinder pastoralists' capacity in harnessing the available opportunities for sustainability of pastoralism (Wakhungu *et al.* 2014). The shrinking rangelands as a result of land subdivision for human settling and other commercial ventures have raised questions on the sustainable pastoralism in the County

2.3 Climate Change and variability

Weather can be defined as daily condition of temperature, rainfall, wind or humidity as presented in the atmosphere while climate is mean of temperature, rainfall, wind or humidity measured for a duration of time frame that ranges from months, years to decades. Variability in climate is the mean statistical variations of climate parameters measures on spatially or temporally defined scales. Climate change is a change on the mean of the climate parameters over a long period of time usually over years, decades or centuries but according to World Meteorological Organization (WMO), classically is a period of thirty years. While climate variability is normal variation in climatic parameter from its long-term mean of a region and is generally attributed to natural causes, climate change is indirectly or directly being attributed to activities that are human in nature in addition to the natural climatic variables. Climate change is thus contributing immensely to climate variability.

Climate variability and change response may involve development of strategies that could reduce their effects on the livelihoods and at the same utilize any opportunities that may arise during the implementation of the strategies but this would also require availability of information regarding temperature and rainfall trends (Bobadoye *et al.* 2016). The variability or change in climate especially in rainfall and temperature impact heavily on pastoralism since rainfall and temperature would determine the availability of pasture and water which are critical in pastoralism as a practice. Climate variability and change affects livestock as a production system as livestock productivity would be determined by presence or absence of livestock diseases and availability of pasture, fodder and water (Rojas-Downing *et al.* 2017). The effects are expected to be felt more as there will be an increase on the average surface global temperature by the 2100 (IPCC, 2013), Thus affecting livestock productivity and by extension pastoralism as a livelihood source for the pastoral communities in the ASALs.

IPCC (2007) gave overwhelming evidence that the changes in climate are real and that the changes are expected to be worse. The report further stated that the poorest community are likely to be affected more with the climatic changes and that climatic changes present very worrying challenges to humanity in the 21st Century globally. Although climatic changes have been observed through the evolution of the earth's climate over millennia but rapid production of greenhouse gases over the last two centuries has accelerated the changes in climate. Syed *et al.* 2010 reported that the global warming has led to acceleration and intensification the water cycle of all over the world resulting in violent storms, recurrent floods and frequent droughts. According Chu *et al.* 2010, intensification of water cycle could influence human

activities further accelerating climatic changes. Such human activities that are likely to accelerate changes in climate could include over exploitation of water for production of energy and water supplies for consumption, industrialization, food security concerns, human health and ecosystems. However, changes that might occur in water cycle due to influence on human activities might differ from region to region depending on the specific region in the world (Khattak *et al.* 2011).

UNFCCC (2010); IPCC (2014) and Mahmood and Jia, 2018 reported that change in climate is becoming a major threat to the developing and developed countries with the developing countries within the African continent more likely to be most affected since they are less equipped to deal with the impacts climate variability and change. According to Serdeczny (2017), African continent is prone to the effects of climate variability and change especially on water resources and therefore specifically being highly vulnerable to climatic changes. According to Ingrid *et al.* 2009, globally observed warming was leading to increased incidences of drought that in effect was creating shocks that are destroying the regenerative capacities of the environmental and human systems. This led to poor generation in vegetation as rainfall was too erratic, either too short or too low in quantity. Due to the scarcity of vegetation, there was low productivity in livestock and loss of livestock as result of inadequate pasture for grazing or exhaustion as pastoralists move with their livestock searching for pastures in other areas.

Boko *et al.* 2007 reported that out of the total biodiversity of Africa, up to 50% was under risk due to reduction in habitat and other pressures that have been induced by human activities. Pastoral areas within Africa are currently under pressure as a result of climate stresses and this has increased their vulnerability to the impacts of climate variability and change as most parts of Africa have very variable climate with droughts and floods occurring concurrently. This is therefore leading to disruption of socio-economic activities and widespread famine calling for food relief for Africa most of the time. According to UNFCCC (2007), about one third of African people including the pastoral communities are living in areas that are prone to droughts and therefore 220 million people in these areas are being exposed to drought virtually every year.

The rise in global temperature is accelerating the speed at which climatic change is occurring and has therefore created the urgency for reducing the vulnerability and increment on the capacity to adapt to climate variability and change for the countries which are still developing by implementing climate change adaptation plans. The development path that would be

pursued and changes in climate will determine the future vulnerability of these countries. The implementation of adaptation plans should follow national guidelines and globally recognized sustainable development efforts towards climate variability and change. The developed countries should be called upon to help in identifying resources and tools that could be used to support adaptation efforts towards climatic changes being observed in the developing countries. This should include the countries that are occupied by the pastoral communities since these communities are increasingly becoming vulnerable to climate change effects.

Climate projections for the ASALs is still very uncertain due to unpredictability associated with these areas but according to the IPCC's Fourth Assessment Report, regional projections that include for both pastoral and sedentary farming areas are designed for longer periods of time, nearly 20 years but efforts to have more local projections have been ongoing and local projections are now available. Although the extent of impacts of climate change still remains uncertain in developing countries but the current available knowledge and information on strategies and plans for implementing adaptation strategies are sufficient for the developing countries to act on (UNFCCC, 2007).

Osbaahr and Viner (2006) reported that ASALs some parts of Kenya especially northern parts would be experiencing decrease in rainfall in the medium-term seasons but according to Nassef *et al.* 2009, the situation was likely to be for more intense rains the longer term seasons. The vulnerability of ASALs in East Africa is resulting from socioeconomic factors and climatic changes. There is a fear that livelihoods of pastoralists living in East Africa is increasingly more becoming unsustainable compared other forms of livelihood since the pastoralists are likely to become "the first climate refugees" under the changing climate (Thornton *et al.* 2007) Increment in variability of climate parameters could lead to reduction in the number of animals kept by individual pastoralists due to decreased reproductive performance of the animal that may accompanied with livestock mortalities. The reduction on herd size is a threat to food security as the production of livestock and livestock products which the pastoralists rely on for food and other social benefits are going to be compromised (Herrero *et al.* 2016)

Kenya had experienced an increment in the frequency of drought after every ten years during the 1960/70s but this reduced to a frequency of every five years in the 1980s (Nkedianye *et al.* 2011; Huho and Mugalavai, 2010). Thereafter, this drought frequency decreased to one after every two to three during 1990s but the drought has become unpredictable as from the year two thousand. A marked increment in frequency of drought risk was likely be observed

in much of Eastern Africa 2050s (IPCC, 2012) and this was expected to threaten the economic sectors such as pastoralism that are dependent on climatic conditions. Livelihood populations such as pastoral livelihoods that are dependent on natural resources have serious challenges with frequently occurring drought (Nicholson, (2014); Below *et al.* 2010). Kenya's ASALs have faced increasingly intensified droughts since the 1960s and ASALs are very vulnerable to frequently occurring droughts in the Country (Nkedianye *et al.* 2011). According to Thornton and Lipper (2014), ASALs would most likely experience climatic extremes that might be extreme, increment in water stress and reduced yields especially from rain-dependent agriculture with the end result being malnutrition and food insecurity and climatic changes would more likely have greater effect on livestock productivity, agriculture and incidence of pathogens, diseases and vectors of livestock through the influence on environment (Pinto *et al.* 2008).

The impacts of climate variability and change on human health, epidemiology of diseases and pests that are infectious, how vector-borne diseases that include blue tongue, malaria and rift valley fever are distributed need to be determined. According to Martin *et al.* 2008, national, regional and global systems that could provide early warning information need to be strengthened. Research programmes and intervention measures should be well coordinated to enable planning through appropriate adaptation strategies by the pastoral communities to respond to the changing climatic conditions. The Maasai pastoralist communities in Kajiado County just like other pastoralist communities are already experiencing climate change and variability effects through prolonged droughts and high temperatures. Therefore, coping strategies that could address climate change effects in Kajiado are required through swift action by both the pastoralists themselves and the County government. The climatic changes would increase vulnerability within pastoralists' livestock-based livelihood system which is intimately tied to the local resource bases that are also climate-sensitive. The number of livestock is expected to reduce due to emaciations and livestock diseases with the resultant deaths hence putting sustainability of pastoralism at stake in the County. The number of animals owned by individual pastoralists, livestock breed and type, availability of credit facility and grazing land and migration of livestock are some of the factors that may determine pastoralist's ability to cope with the impacts of climate variability and change during extreme weather conditions and reduction of vulnerability to such weather conditions (Bobadoye *et al.* 2018)

2.4 Sustainability of Pastoralism

Higher temperatures and increasingly but frequent extreme weather conditions that are being projected for the ASALs might worsen the problems of pastoralism and development in the ASALs. Adaption to climatic changes and achievement of enhanced development that is sustainable within the ASALs is possible with the right enabling policies (Pekka *et al.* 2011). Although changes in climate are a threat to sustainable livestock production globally, the threat is more real in the pastoralist areas where the livestock production systems rely highly on the climate-sensitive natural resources. Ingrid *et al.* 2009 reported that within the pastoral areas, there is very little diversification of resources as the pastoralists relies mainly on livestock keeping to support their livelihood. The fact that keeping of livestock depends on climatic conditions and that pastoralists have limited alternative sources of livelihoods, their vulnerability to impacts of climate change is very high. According to Sejian *et al.* 2016, livestock is the major livelihood source for the majority of people living in the rural environments, pastoral areas included. With the occurrence of climate variability and change, there is need to look for solutions that would maintain livestock production as a viable economic enterprise but also reducing impacts of climatic changes and environmental pollutants and enhancing profitability of livestock productivity.

Climatic changes associated with recurrent droughts are piling a lot of pressure on pastoralism. These challenges have brought the realization that there is need for analysis of pastoral production systems with the view to establishing whether the production systems can be sustained under these challenges or they require support through some legislative framework (Tessema *et al.* 2014). Sustainable pastoral systems may be more resilient, efficient and productive compared to other forms agricultural activities such as sedentary agriculture within the same ecological zones with the same climatic conditions. Even before the advent of climate change, pastoralists have had indigenous knowledge on their environment that has been guiding them in the protection and exploitation of the frequently changing dry land conditions for sustainability of pastoral livelihood (McGahey *et al.* 2008). According to Notenbaert *et al.* 2012, pastoralists are trying to adapt and cope with the climatic conditions that are increasingly becoming extreme especially drought for sustainability. Pastoralism as a production system is still marginalized politically, socio-economically and environmentally further complicating its sustainability under the changing climatic conditions (Schilling *et al.* 2012). Pastoralists are developing coping and adaptation strategies to climatic

changes at a micro scale that are aimed at addressing complex drought situations to sustain pastoralism (Osano *et al.* 2013; Silvestri *et al.* 2012; Speranza (2010)).

Kelemework (2012) reported that pressure from climate change, policies that do not favour pastoralism, poverty and increase in human population are making pastoralism within East Africa region to be become increasingly unsustainable thus calling for the pastoralists to think beyond pastoralism. Therefore, the current and future climate parameters among other factors, would determine the sustainability of pastoralism in the future. According to Kimaro and Chibinga (2013), recurrent and persistent challenges facing the pastoralists under the changing climate would be reduced if current and future climate parameters are fully understood by the pastoralists. Lind and Barrero (2014) reported that pastoralists' contribution to regional and global economy should be given recognition so that they can be enlisted in capital development regionally and globally. This could be done through establishment of commercial ranches and marketing facilities and expansion of road networks and telecommunications for promotion of livestock trade in the pastoral areas. This could accelerate commercialization of livestock and encourage investment by private sector in the ASALs with improvement on the livelihoods of the pastoralists and reduction in vulnerability to climate change effects.

There is growing pressure on pastoral production system which is a customary-based livestock production system centered on livestock movement and accessibility to resources that depend on climate climatic conditions. There is already concern that pastoral livelihood in Kajiado County is fundamentally becoming unsustainable as the pressure from climate variability and change intensifies. The situation is worsening as there are no predominant policy, developmental strategies and approaches in place to successfully explore new options and opportunities aimed at salvaging the pastoralist livelihoods under a changing climate. Sustainability of pastoralism under the changing climatic conditions could be achieved if the adaptive capacity hinged on sustainable pastoral development is well understood by the pastoralists. According to Nori and Davies (2008), restoration and enhancement of adaptive capacity should form the basis of developmental plans for the pastoral areas although this would require flexible use of available natural resources that could be affordable to pastoralists for provision of security to their livelihood under the pastoral environment. The adaptive capacity would make the pastoralists to become resilient and exploit their natural resources sustainably although the pastoral areas are gradually losing their adaptive capacity

due to climatic changes that has resulted in depletion of resources, degradation of environment and impoverishment.

Although migration has been the most popular coping strategy for the pastoralists during the past droughts when coping with extreme weather conditions and other related challenges, the movements have become increasingly impossible due to climatic changes that affect the natural resources that are supposed to sustain pastoralism. Growing population and shrinking of rangelands are putting a lot of pressure on the pastoral production system with migration itself becoming a big challenge for the sustainability of pastoralism since the new areas the pastoralists could move to during dry periods for grazing are equally affected by the changing climate. Resilience of pastoralists in Kajiado has been dependent on the indigenous knowledge that makes them understand their environment, livestock production system and the customary-based institutions for their benefit.

Kajiado County is experiencing a rapid transformation of land as a result of increase in human population, sale and subdivision of land for human settlement and industrialization and acquisition of urban status of most local markets. This has changed the response strategy to climatic changes by pastoralists in the County and how they are sustaining their pastoral livelihood (Moiko, *et al.* 2019). According to Reid *et al.* 2007, the pastoralists need to be concerned with the risks the current climatic changes might present to them rather than citing non-climate related threats that they might think are more important. Generally, there is very little understanding on how pastoralism as a production system works by governments in view of the changes in climate and governments have failed to get views on the system from the pastoralists themselves resulting in divergent opinions about pastoralism in ASALs. This in effect has created challenges for development planning and policy making leading to development failures in the ASALs. Coupled with the level of poverty which has been complicated further by impacts of climate variability and change, there are serious policy challenges for policy makers in the ASALs.

Awareness creation on the risks associated with climatic changes should be done for pastoralists in Kajiado to enable them develop new adaptive strategies under the changing climate for sustainability of pastoralism as climate change and variability would most likely accelerate and increase environment and social changes. Serious consideration need to be given to sustainable rangelands management by the pastoralists if pastoralism is to be sustained in the County. Sustainable pastoralism in the County would be determined by the land tenure system that would also determine the strategies and options available for the

pastoralists to pursue regarding investment on land and adaptation to climatic changes (Moiko, *et al.* 2019).

2.5 Climate change impacts

According to Hassan (2010), effects of climatic changes predictably may be worse especially for pastoral production systems within Africa because of the already marginalized environment with water stresses. Climatic changes are happening unequivocally at an unprecedented rate and the effects could severely affect the ASALs (Huang *et al.* 2016; Adhikari *et al.* 2015; IPCC (2013)). Effects of climate change within Africa are associated with variability in rainfall pattern, recurrent droughts, flooding and stormy winds (IPCC, 2007 and IPCC, 2013) and many factors are contributing and compounding the current impacts within Africa as a continent. The expected negative effects could reduce Africa's ability in coping with climatic changes. The coping ability of Africa is further complicated by low literacy level, poor health care, low poverty level, limited access to resources, armed conflicts, poor infrastructure and weak institutions. Effects of climatic changes result from average climatic conditions that affect economic, health and natural systems (IPCC, 2007). The effects climate variability and change on ASALs and the vulnerability of pastoral communities living within these areas would be worse and divergent thus requiring immediate and sustained actions (Herrero *et al.* 2016).

According to Toulmin (2009) and Nardone *et al.* 2010, changes in climate are expected to affect pastoralism as a production system with cattle being more affected compared to other species of livestock due to their feeding habit and being sensitive to heat stress. Climate change impacts to ASALs within East Africa are considered to be very severe since the ASALs in the region have weak institutional governance systems that are not able to support climate-related issues. Tanzania has over 50% of the total land mass covered by the ASALs while Kenya has 80% of its land covered by ASALs, with climate change affecting most of the pastoralists and other rural populations living within the two countries (Filho *et al.* 2017).

Vulnerability to climatic change effects is considered more severe within the developing countries compared to the developed countries due to the limited pool of resources for financial, social and technological adaptations in the developing countries. Effects of climatic changes expectedly would be felt severely on sustainable development and pastoralism by the developing countries (UN, 2007). Egeru (2016) reported that it is important to have climate risk information that could assist in shaping the actions that could be taken against effects of

climatic changes while Patt and Schröter (2007) and Adger *et al.* 2009 reported that perception of climate risk by individuals and groups could determine the actions to be taken against effects of climate change. Perception of a threat to climatic changes as compared to risks associated with the changes seem to play a greater role when accepting to implement an adaptation strategy. Therefore, for a community to effectively and appropriately implement adaptation strategies, their perception on climatic changes need to be well understood (Ernoul *et al.* 2020). Maladaptation or failure to adapt could result from misconception of climate risks. Climate change impacts usually differ from region to region but on rangelands where pastoral activities are being undertaken, climate variability and change predictably would affect pastoralism more compared to high potential areas. Researchers need to put more emphasis on rangelands with pastoral production systems and the research findings should be able to inform policy makers on the right policies for pastoral areas (Wassie and Fekadu, 2014). However, Morton *et al.* 2016, noted that researchers have had simplistic and polarized discussion on how climate variability and change affects pastoralism with a number predicting serious consequences for the pastoralists in future. Some researchers still hold the opinion that pastoralists have the ability to adapt provided there are policies that allow emission of greenhouse gases although there has never been any research finding to ascertain what pastoralism contributes to the emission of greenhouse gases.

Changes in climate significantly affect the pastoral production systems. This calls for inclusive discussions on climate change ensuring that ability of pastoralists to adapt or their vulnerability to impacts of climatic changes are taken care of during such discussions. According to Anderson, *et al.* 2009, knowledge gap establishment and helping pastoralists to know what could be done when adapting to impacts of climatic changes could make them fit into discussions on climate issues. This would assist in finding solutions that could help the pastoralists within ASALs to reduce climate variability and change impacts. Agriculture and livestock are some of the economic sectors that depend on climatic conditions within the ASALs and high potential areas (Speranza, 2010). Livestock sector especially within ASALs, has suffered from recurrent droughts with resultant loss of livestock body conditions, increase on livestock disease incidences and livestock deaths. While in high potential areas, variability in temperatures might not have much effect on livestock and pasture productivity, in ASALs the impacts of variability might be negatively felt in many specific areas (Herrero *et al.* 2016) Climatic changes have the ability to alter incidence of diseases and consequently affect animal and human health (Raninowitz and Conti, 2013). The impacts of climate variability and

change and which might be indirect or direct are as a result of changes in climate parameters such rainfall and temperature (Lacetera, 2018). The direct impacts might be in terms of clinical illness or deaths as result of extreme weather conditions while the indirect effects might be observed through the increased incidence and distribution of disease-causing pathogens (Lacetera, *et al.* 2013). Gardner (2012) noted that livestock diseases affect survival of livestock through animal health, market for livestock and consequently the livelihoods of those that depend on livestock production for their rural economy.

Kimaro *et al.* 2013 noted that several studies have been undertaken on impact of climate change and human health within East Africa region but little research has been undertaken on effects of climatic changes on animal health disregarding the economic contribution of livestock and agriculture within the region. This has created a gap on knowledge that is affecting management of livestock as an enterprise and development of livestock projects within the region. This has in effect affected socio-economic, water and environmental sectors with adverse effect on food security, biodiversity and ecosystems. Sejian (2013) reported that climate extremes coupled with seasonal fluctuations could result in reduction on quantity and quality of pasture and this would affect the efficiency in production and reproduction of an animal thus affecting pastoralism as a production system. According to UNFCCC (2007) and WSPA (2012), changes in climate would affect meat, milk and dairy production in the ASALs and that these production systems play major role in nutrition and livelihoods support.

Vitali *et al.* 2009 and Vitali *et al.* 2016, reported that there was risk of livestock mortality during hot periods and increment on livestock losses during such periods. According to Forastiere, 2010, behaviour of a community such as migration, socioeconomic interest and environmental surrounding are some of the factors that could determine impact of climatic changes on the health of an animal. Robinson *et al.* 2013 and Coffey (2008), stated that temperature rise could cause warming and stress in animals and this would lower the intake of feed with resultant reduction in growth, reproduction and occasionally mortality in animals. Major impacts of climate change on livestock are basically on reproduction and feed and forage quality (IFAD (2010); Chapman *et al.* 2012; Polley *et al.* 2013). The effects of climatic changes on diseases of livestock would depend on land use, geography of a region, the behaviour of the disease and how susceptible the animal is to the disease (Thornton *et al.* 2009).

According Nardone *et al.* 2010, climate variability and change would directly or indirectly affect animal health but that increment in temperatures would more severely affect the health

of the animal. The direct effect on animal health is through increment on temperature and this increases the morbidity of the disease and possible death of the animal while the indirect effects are associated with increase on disease pathogens or parasites, spread of vector-borne diseases, scarcity of water and reduced and low quality feed and forage (Tubiello *et al.* 2008). Climate variability might alter disease occurrence pattern, cause severe outbreak of some diseases or cause introduction of new livestock diseases thus adversely affecting the livestock due to new exposure (Thornton *et al.* 2009). Desalegn *et al.* 2018 noted that variability in climate parameters would have severe effect on livestock production either indirectly or directly through increment on incidence of animal diseases, reduction in productivity and production losses.

The changing climate has increased the vulnerability of pastoralists in Kajiado County and although pastoralists are mitigating the effects of climatic changes by changing the pattern of feeding their animals, the responses are still inadequate due to existing knowledge gap on how on how to respond to the changes in climate (Mukuna *et al.* 2015). Therefore, this is raising concern on the current climate change adaptation options being practiced by the pastoralists as the effects on pastoralism are already being felt, calling for interventions that would build the pastoralists' resilience in the short term and adaptive capacity in the long term. According to Drucker *et al.* 2007, efforts should be made to identify adaptation options that could reduce vulnerability and build resilience among the pastoralists' communities living in ASALs. The adaptation intervention measures should take into account the livestock production dynamics and structures, key indigenous breeding strategies and indigenous management skills of the pastoralists' climate-sensitive natural resources.

2.6 Adaptation to climate variability and change

Adaptation to climatic changes is necessary when reduction of vulnerability to extreme climatic conditions such as recurrent and frequent droughts or floods is required. The strategies might also be necessary in preparing individuals or communities for any possible extreme climatic events. According to IPCC (2007) and IPCC (2012), climate change adaptation strategy is a natural or human system adjustment which is made as a response towards actual or expected stimulus from climate. It can also be the effect of the stimulus aimed at moderating any harmful effect or exploiting beneficial opportunities of the effect. Adger *et al.* 2007 reported that adaptation is the adjustment done by individuals or communities for the purpose of reducing household vulnerabilities to climate change. Migosi *et al.* 2012 described adaptation as long term adjustments made to livelihoods during

environmental changes while coping as temporary adjustment or short term adjustment. It is made when responding to environmental change or mitigating shock or stress that is affecting livelihoods.

Adapting is the ability to make decisions when faced with great uncertainties but even with the available information on climatic conditions from meteorological department, pastoralists are still being faced with uncertainties when responding to changes in climate (Crane *et al.* 2011; Roncoli *et al.* 2010). According Kurukulasuriya and Mendelson (2007), adaptation forms the policy option to inform on the response strategies that could reduce impacts of climate variability and change. Adaptation to climatic changes should aim at neutralizing severe impacts of extremely varying climatic conditions and should be critical in combating effects of climate variability and change within the pastoral production areas especially so on livestock (Sejian *et al.* 2015). Pastoral communities require policies that would facilitate their adaptation processes and recognize that changing climate would alter their pastoral livelihoods taking into consideration the fact that pastoral communities have been adapting to continually changing environment even before climate change became a concern (Nassef *et al.* 2009; Nori and Davies, 2007). This would require that climate projections for the pastoral areas be increased to reinforce their ability to adapt with the advent of climate change.

Adaptation is considered successful when vulnerability of the targeted population is reduced and their capacity to predict and adapt to expected climatic changes is strengthened (UNDP, 2007; IGAD, 2007). Some recent studies have indicated that adaptation to climatic changes by the vulnerable populations would be more effective when local institutions with established and sustainable mechanisms that could handle harsh climatic conditions are used (Agrawal, 2008). The dependence of an economic activity on climatic conditions and how resilient the country's social structures are to the changing climatic conditions could determine the impacts of climate variability and change (Barnett and Adger, 2007).

The purpose of climate change adaptation measures for the pastoralists should be to increase their ability to adapt and make them less vulnerable to impacts of changing climate. The challenges the pastoralists face with climatic changes could be reduced if the pastoralists make decisions that reduce potential harm and at the same time exploit new opportunities for their survival (Thorarinsdottir *et al.* 2016). Some of the adaptive strategies that the pastoralists have developed to enable them cope with the harsh arid and semi-arid environment have included socio-economic support networks and herd splitting and diversification. The strategies are waning off as a result of increased variability in climatic parameters calling for rethinking of

new strategies that would appropriately address the challenges associated with the changing climatic patterns (Kelemework, 2012). Therefore, the pastoralists now need to develop new strategies such as sedentary lifestyle, trade and crop farming wage labour, that would enable them cope with the changing environment.

Adaptation and mitigation are two types of measures that are necessary in confronting climate change (IPCC, 2007). While mitigation measure makes it possible to limit changes in climate, adaptation measure reduces vulnerability of social, economic and natural environments of a population. According to IRG-USAID (2008), adaptation is a response whose aim is to reduce vulnerability of bio-social environments under a changing climate and would be seen to have been undertaken if an appropriate measure has been taken to minimize or prevent any damage that could be caused by impacts of the changing climate. Adaptation could also result into utilization or exploitation of opportunities that come from impacts of the changing climatic conditions. Communities may naturally develop coping strategies to ensure the best possible standard of living in the event of climate change and variability (IRG-USAID, 2008). According to World Economic Forum (2014), decision makers should identify and prioritize adaptation measures and allocate adequate resources that would enable the pastoralists build resilience to climate change.

Increasing human population, industrialization, globally changing economic measures and climatic changes are aggravating the problems for pastoral production systems all over the world. Readiness to adapt or the capacity of people to innovate and create solutions should be part of the adaptation process (WEF, 2014). Peoples' readiness or ability to adapt will be determined by internal factors that include positive emotional disposition, the belief that have the capacity, their future orientation with the adaptation, the hope they have in the adaptation, optimism and self-regulation and external factors that include socio-economic and political support. Understanding how population perceives change in climate and involvement of the community are key elements when planning for adaptation strategies (Bobadoye *et al.* 2016). Well planned and early adaptation action will not only save money but also lives. When planning for adaptation action in the pastoral areas, it is necessary to incorporate the indigenous knowledge of the pastoralists since the knowledge has been very useful for the pastoralists to adapt to their ever changing environment even before climate change became a challenge to them.

When dealing with harsh environmental conditions, pastoralists have always acquired locally-tailored knowledge which they have been passing from one generation to another for continuity

of pastoral production systems (Maware, 2015); Chanza *et al.* 2016). Enock (2013) and Orlove *et al.* 2010 noted that researchers have developed interest on indigenous knowledge concept from the 1970s and therefore has been used in research studies on effects of climate change on land, vegetation and agriculture with good results (Katjiua and Ward, 2007). According to Muller and Shackleton (2014) and Wiid and Ziervogel (2012), indigenous knowledge concept has more recently been used in research studies related to how communities adapt to changing climatic conditions and their perception under the fast changing climate. Studies done by Newsham and Thomas (2011) in Namibia and South Africa indicated that indigenous knowledge has been widely used to make decisions on pastoral developmental issues with some degree of success. Angula *et al.* 2016 further noted that indigenous knowledge becomes more useful when it used for complementation and integration in scientific research dealing with climate change within pastoralists' communities. Indigenous knowledge could be useful when communicating, disseminating and utilizing messages on climate change adaptation and mitigation options for the pastoralists (Ajani *et al.* 2013). Wiid and Ziervogel (2012) reported that indigenous knowledge would shape risk perception on climate change and how the risk would be viewed by the pastoralists for decision making on and designation of climatic change responses.

The adaptation measures being undertaken by the pastoralists in Kajiado aimed at protecting livestock against effects of climate change. Rainfall and temperature patterns determines the kind of adaptation response being put in place to safe guard the livestock under a changing climate. Although there are current adaptation measures being practised by the pastoralists in the County, there is need to identify appropriate adaptation strategies that might reduce risks that might be associated with the changes in climate in the County. Mobility remains a much-utilised strategy by pastoralists to cope with climate hazards (Carabine and Simonet, 2018). According to Moiko *et al.* 2019, vulnerability of pastoral community of Kajiado to the changing climate would increase with fragmentation and enclosure of pasture land as this inhibits flexibility and access to strategic resources. With the increasing human population and effects of climatic changes, the pastoralists need extra support to develop sustainable adaptation options (Moiko *et al.* 2019). Designation of adaptation strategies that could effectively address effects of climatic changes would require appropriate knowledge on the future projected impacts. Therefore, this would require collaborative effort among the researchers, affected communities and policy makers (Benedikt *et al.* 2019).

2.7 Opportunity and challenges under a changing climate

Climate change challenges have disrupted the pastoralists' ability to use their own knowledge which they have been relying on when coping and mitigating against effects associated with arid environment. Such coping mechanisms have included adoption of livestock production activities that improve livestock productivity and enhance the pastoralists' resilience. The increased challenges from climate change, requires that the pastoralists apply other strategies other than indigenous knowledge that could assist them address impacts of changing climatic conditions. In addition to their indigenous knowledge, pastoralists require improved extension services through the government services to enable them improve on mitigating options that could support their pastoral livelihood.

Pastoralism is practiced universally across the world in developing and developed countries, with pastoralists within these countries differently facing varying challenges socially and economically but generally pastoral production systems commonly share challenges that relate to economic development, environmental conservation and development and low adaptation capacity to changes in climate. Even with the availability and accessibility of information on changing climatic conditions and change from mobile pastoralism to sedentary pastoralism in some pastoral areas through provision of water and pasture, vulnerability of pastoralists to the rapidly changing climatic conditions is still on the rise (Muchuru and Nhamo, 2017). The challenges of development in pastoral areas is partly being contributed by the fact that pastoralists have not developed appropriate adaptation strategies that could support livestock productivity under the changing climate as they continue to experience low livestock productivity due to livestock losses and poor productivity with the risk of food insecurity and increased poverty levels (Nkuba *et al.* 2019).

According to Birch and Grahn (2007), climate change coping and adaptations options are tied together with the indigenous social and resource management structures that have been put in place by the pastoralists to manage their unique ASALs. The climate change being experienced globally through variations in temperatures and rainfall patterns is causing a shift in management of resources by the pastoralists. Therefore, pastoralism as a production system is now facing new challenges that the pastoralists have not experienced before with expected serious effects on the livelihoods. Wassie and Fekadu (2014), reported that pastoralism is not only facing challenges from the global climate change but also from non-climatic factors such as bad governance and subdivision of rangelands for human settlement as a result of increase in population growth and commercial enterprises.

According to Silvestri *et al.* 2012, some of the challenges being experienced by the pastoralists are as a result of the pastoralists not being able to use their traditionally known coping mechanisms such as ability to migrate with livestock across borders during drought, non-restricted free trading in livestock and participating in policy decisions that affect their livelihoods. Although livestock production system in ASALs has been known to be very resilient, the pressure being exerted by climate change on the system through the impacts poses a serious challenge on sustainability of pastoralism as a form of livestock production system. Coupled with social, economic and political marginalization that the pastoralists are faced with, climate change is giving another dimension on the pastoral livelihoods. Kirimi *et al.* 2013 noted that pastoralists might now require more than the indigenous knowledge they are used to due to increased challenges emanating from climate change. Such options should include improved livestock extension services that would improve pasture productivity and conservation to minimize movements as climate change is aggravating challenges in pastoral production areas such as increased community/clan conflicts and management and control of resources such as water and pasture that are critical for the sustainability of pastoralism.

Ingrid *et al.* 2009 reported that communities in ASALs keep large number of animals in an environment that is uncertain and to sustain this livelihood under the uncertainties, pastoralists have developed networks and strategies that they use to exploit this unpredictability and the associated risks for their advantage to maintain their livelihoods. With these challenges from climate change, pastoralists would now have to reconsider their traditional livestock keeping system of large herds of cattle and adopt other alternative livelihoods that might be less dependent on climate. According Nkuba *et al.* 2019, use of climate information may improve resilience of the pastoralists against climate-related risks. Some of the key challenges associated with climatic changes and that are reportedly facing pastoralists in Kenya are inadequate pasture and water due to recurrent and prolonged droughts, high incidences of livestock diseases caused by uncontrolled movement livestock and low pasture productivity. The higher temperatures and occasional intensified rains that are being projected for ASALs might worsen problems in the rangelands when it comes to contribution on development and food security. Pastoralism is the major livelihood source for the of livelihood for most of the inhabitants of Kajiado County but effects of climate change are exerting pressure on pastoralism as production system with the pastoralists' livelihood being exposed to climate associated vulnerabilities.

With the right policy environment, pastoralists could still have a sustainable and productive future even with the changing climatic situations. Therefore, there is need to secure and strengthen pastoralism as a major economic activity in ASALs but this should be coupled with livelihood diversifications. Building resilience of the pastoralists to adapt is important when addressing some of these challenges. As the inherent adaptive capacity of pastoralists are being strengthened, their autonomous adaptation should also be encouraged rather than wholly providing adaptation strategies for them but at the same time the pastoralists should be able to access viable and sustainable alternative or supplementary livelihoods if they are to survive under the changing climate.

CHAPTER THREE

METHODS AND MATERIALS

3.1 INTRODUCTION

The chapter gives description of the methods and materials that facilitated the study including area of study, research approach and design, sampling method, sample size determination, collection of data, data management and analysis and conceptual framework.

3.2 STUDY AREA

3.2.1 Description of Area of Study

The research was conducted in Kajiado County that is located in the Kenya's southern part. It lies within Latitudes 1° 0'; 3° 0' South; Longitudes 36° 5'; 37° 5' East with an area coverage of 21,900.9 Km². The County borders Nairobi County on North East, Machakos and Makueni Counties on East, Nakuru and Kiambu counties on North, Narok County on West, Taveta County on South East with United Republic of Tanzania on South West. Main physical features in the County include valleys, plains and volcanic hills. Kajiado County is inhabited majorly by Maasai pastoral community, most of whom are found within the rural areas of the County with cosmopolitan population found mainly in market and town set-ups.

Pastoralists in the County majorly practice pastoralism but there is also crop farming coupled with horticultural farming that is being done in some parts of the County, depending on the ecological zone, to support livelihoods. There are four livelihood zones: mixed farming, marginal mixed farming agro pastoral and pastoral distributed within the County's five sub counties. Pastoralism majorly is practiced in Kajiado Central, South, West and East while in Kajiado North there are sedentary livestock keeping and crop farming systems. Recurrent droughts, flash floods and environmental pollution and degradation are some of the climate change related disasters that are occasionally being experienced in the County. The human activities such as tree cutting for charcoal burning have been observed to have attributed to serious environmental degradation predisposing the County to the adverse weather conditions. Figure 1 shows the Map for Kajiado County with the administrative units (sub counties).

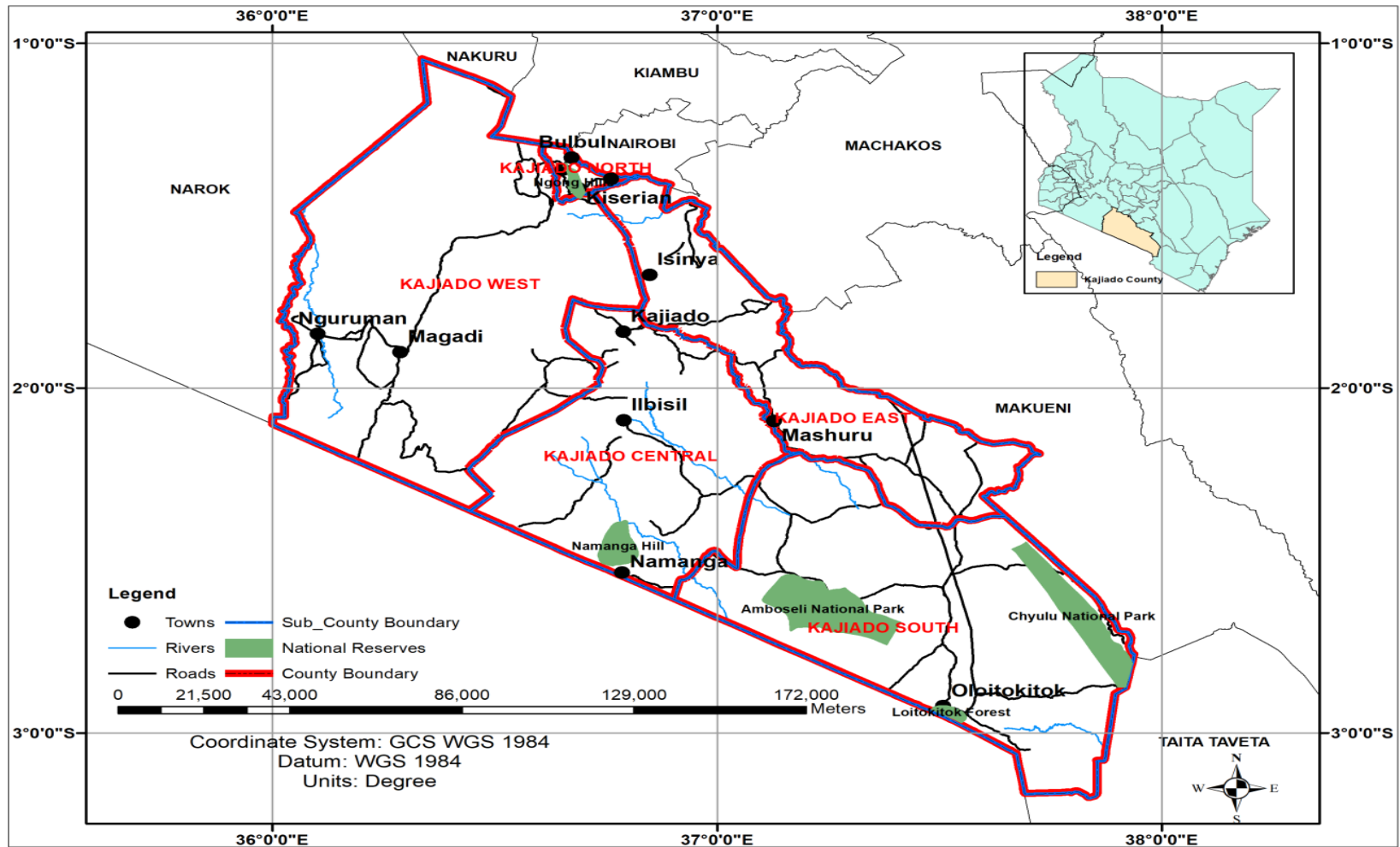


Figure 1: Map of Kajiado County with sub county administrative units

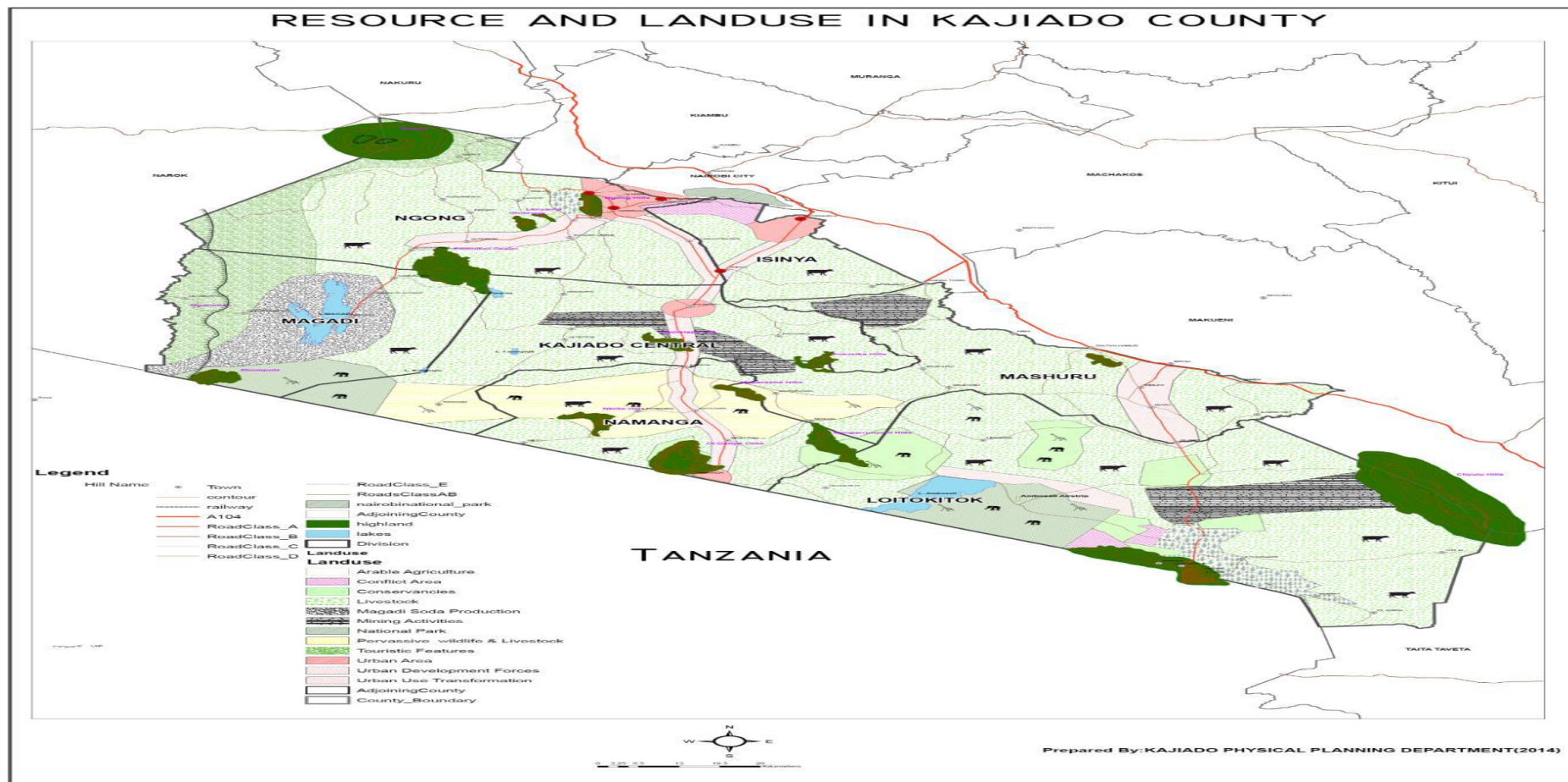


Figure 2: Resource and Land use in Kajiado County

3.2.2 Resource and land use in the County

Figure 2 above shows land use and resource distribution within the County. The county is endowed with vast land and diverse land resources within its semi-arid lands. Land is a very crucial factor of production and development within Kajiado County. As a production factor, land supports pastoralism as the major livelihood for the majority of the pastoralists (Maa Community) living in rural areas of Kajiado. The land is also supporting small and medium scale crop farming that is being practiced within high potential areas such as Ngong, Loitokitok, and Nkurumani and other farming activities that include flower farming, practiced mainly within Isinya and Kitengela areas and horticultural farming which is also picking up targeting both the local and international markets.

As a development factor, land is supporting industrial and housing development, quarrying and mining and human population among others. The proximity to the Nairobi City has increased demand for land putting a lot of pressure on the pastoral grazing lands. Increase in human population, unpredictable weather and demand for industrialization, has seen rapid development taking place within rural and urban across the county. These include increase in industrial and housing development, quarrying and mining. The land use is significantly changing from being for pastoral/agricultural use to industrial or commercial use within rural and urban areas. This high demand for land for various uses has significantly contributed to increased land subdivision and fragmentation of agricultural (pastoral) land into unsustainable portions that are affecting the sustainability of the rural livelihoods.

There has been drastic reduction in the number of ranches following the sub divisions further putting the future of pastoralism into jeopardy as livestock are now being constrained in their grazing habits. The number of group ranches has reduced from 56 to only 10 across the County. The 10 ranches are mainly found in Kajiado South and West. This subdivision and sale of land for human settlement and industrial development is significantly reducing the pastoral activities since land that is supporting pasture production is increasingly being converted to other uses other than pastoralism. This has escalated the challenges associated with climate change as the grazing land is getting diminished with pastoralists getting restricted in movement with their livestock especially during the time of drought.

The important natural resources in the County include Amboseli National Park, Ngong Hills, Oloolua Forest, Lake Magadi, Oldonyo Orok in Namanga, Maparasha Hills, Oloorgisalie historical site and several wildlife sanctuaries such as Kimana, among others. Main water

sources include the Tsavo River whose tributaries include Rombo, Nolturesh and Magoine. Major sources of water are dams, wells and water pans as most of the rivers remain dry for the better part of the months.

3.2.3 Social Setting

The main ethnic group in the County is the Maasai community, majority of whom practice pastoralism in the rural areas but there is also an influx of other ethnic communities into the County from other parts of the country who are settling mainly for residential, sedentary livestock keeping, industrialization and horticulture and crop farming. The human settlement pattern in the county is divided into urban and rural. Rural population comprises mainly of the Maasai pastoralists communities while urban population is cosmopolitan. Most urban areas are densely populated and estimated to be at 40% while that of rural areas that comprises mainly of the pastoralists is estimated to be at 60%. According to population census of 2009, the human population stood at 687,312 persons, with population growth rate being was estimated to be 5.5% and population density at 31 people per Km² (KNBS, 2009). Although these were average statistical figures, the population growth rate and population density was not uniform across the 5 sub-counties as urban areas are relatively densely populated compared to the rural areas.

3.2.4 Socio-Economic Setting

Kajiado being semi-arid area with mixed economy, livestock production, agriculture, tourism and mining are independently existing economic activities but livestock production is the major activity supporting the County's economy. Therefore, agriculture, tourism and mining are independently being practiced and can be alternatives for pastoralism but taking up these activities would mean livelihood diversification with the option of pulling out of pastoralism. There is a smaller group of the population that practice subsistence farming (CIDP, 2013) but livestock sector still remains the largest contributor to the County's economy compared to other sectors such as agriculture, tourism and mining. The study could not provide the values on contribution of these main sectors to the County's economy since even the reviewed literature had no values for the same but only gave the importance of the sectors and their general contributions to the County's economy.

The livestock sector provides food in terms of milk and meat (animal protein), income and employment through livestock trade and slaughterhouses. Livestock is also used for cultural activities such as feasts, weddings and/or other celebrations and defines wealth among the pastoralists through the number of livestock owned. The major livestock include cattle, sheep

and goats. Estimated livestock population as at 2018, according to the reports from the Department of livestock, were 685,208 head of cattle, 1,027,595 sheep and 1,202,850 goats. Tourism forms the second major contributor to the County's economy with Amboseli National Park and Chyulu Conservation area being the major tourist attraction locally, nationally, regionally and internationally. Other activities that contribute to County's economy include agriculture and mining although the activities are only being undertaken in some areas the County.

The current challenges that are associated with changes in climate in Kajiado have made some pastoralists to employ mixed livelihood approach and diversification as mitigation strategies. With mixed livelihood approach, some pastoralists are keeping livestock and at the same time engage in crop farming either through irrigation or natural rains. While in livelihood diversification, some pastoralists are opting out of pastoralism to a more viable and sustainable economic activity with very minimal climate change challenges. These include bee keeping, fish farming, zero grazing, feedlots, etc.

3.2.5 Socio-Economic Vulnerabilities

Kajiado pastoralists' community are increasingly becoming socially vulnerable as the impacts of changing climate is being felt within the County further exposing them to multiple stresses. Coupled with high poverty levels, low literacy levels, poor infrastructure, rapidly growing population, industrialization and deforestation mostly through charcoal burning, the community's vulnerability to the impacts of the changing climatic conditions is increasing becoming higher is becoming.

3.2.6 Regulatory Framework

With the implementation of the Constitution of Kenya (2010) in 2013, the Country was divided into 47 counties, Kajiado being one of the counties. One of the important functions that the County has to address in safeguarding pastoralism is land tenure system. Implementation of land policy is crucial for the County as land affects the pastoral activities since pastoralism as a production system relies on vast pastoral grazing lands for their livestock.

The County currently has no proper institutional framework to execute land policy issues and this is greatly affecting pastoralism as pastoral grazing areas are being sub divided into smaller units for sale for human settlements and other industrial developments. The ranches that are meant for grazing of livestock are reducing in number following these sub divisions. Although reportedly, the County Government is in the process of putting in place zoning policy guidelines

that would create zones in the county as follows: residential, industrial, agricultural, pastoralism, conservation and tourism, roads, forests, lake and river basins among others. The County has already initiated the development of County Spatial Development Plan that would be followed by digital mapping and coding of all land records in the County with the aim of creating the intended zones (CIDP, 2018). This is aimed at strengthening land administration and at the same time protects the pastoral grazing areas that support pastoralism as a production system in Kajiado County.

3.2.7 Climate of the Study Area

According to CIDP (2013), Kajiado is generally becoming dry with limited flowing rivers and has been categorized as semi-arid land. The impact of the changing climatic situation is evident within Kajiado County through recurrent and prolonged droughts, increasingly unpredictable and extreme temperatures. The County's seasonal rainfall calendar is bimodal. The long rains are usually observed between March-May with the peak of the season being April while the season for the short rains is October-November-December with December being the season's peak season being December. Figure 3 shows the seasonal bimodal rainfall pattern for Kajiado from Kenya Meteorological Services 1970–2015. According to CIDP (2013), there is no uniformity in the rainfall distribution pattern within the County as the long rainy seasons usually have more rains on the western part and short rainy seasons have more rains experienced on the eastern part of the County. The bi-modal rainfall pattern that has traditionally been boosting crop growing and pastoralism is changing with the weather becoming unpredictable and unreliable leading to devastating effects on the pastoral livelihoods. This is being associated to changes that are being attributed to climate change/variability.

The County is now experiencing very harsh weather conditions especially within and around the sub counties of Kajiado Central and East (CIDP, 2013). Flash floods, high temperatures and very strong winds have now characterised the long and short rainy seasons in the County (CIDP, 2013). The temperatures have been observed to have seasonal and altitudinal variations with the highly recorded temperatures being around Lake Magadi and the lowly recorded around the eastern slopes of Mt. Kilimanjaro but within Loitokitok in Kajiado South. July and August are the coolest months while the November and April are the hottest months in the County. CIDP (2013), further stated that the effects of environmental and climatic changes in the County are already being experienced within the socio-economic environments as there

was water scarcity coupled with water pollution, decrease in pasture productivity and low livestock productivity greatly affecting pastoralism as a livelihood support in the County.

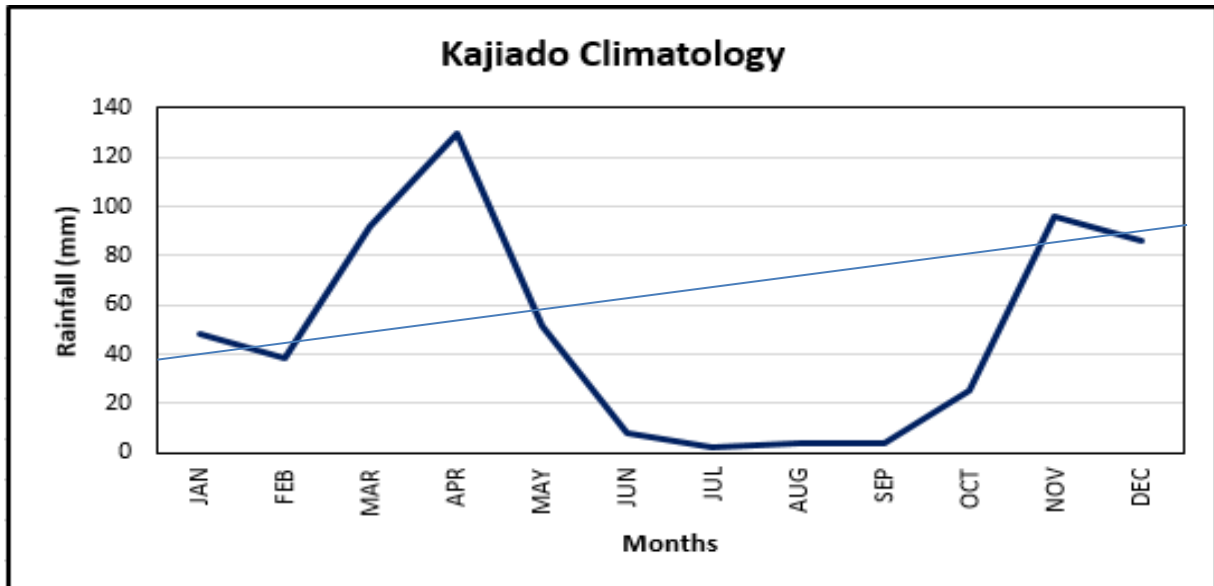


Figure 3: Kajiado County Bimodal Seasonal Rainfall (Source: Kenya Meteorological Department; 2015)

3.3 RESEARCH APPROACH AND DESIGN

Wanjohi, 2014, described research design as a strategy that integrates various parts of a research study with some logistical sequent and understanding. The necessary documents were obtained by the researcher before the data collection process was commenced. After getting authority from Kajiado County to conduct the research study, an extensive survey of the study area was undertaken before the start of the data collection. The tour was to acclimatize with study area, to make contacts with the study population and to introduce the study objectives to the study participants.

During the familiarization tour, the research team met with Maasai pastoral community, community leaders, administrators and other stakeholders whose functions in one way or the other are influencing the pastoral activities in the County. These included the departments of Livestock Production, Veterinary Services, Agriculture and Meteorological Services and NDMA and an NGO working within Kajiado. The meetings were organized through the assistance of village elders, extension workers and chiefs who were familiar with Kajiado County. During the meetings, an assurance was given to the participants that the research being undertaken purposely for academic, that participants are taking part in the study voluntarily and that the participants had the freedom to decline to participate in the study or withdraw from

the study even after engagement with the researchers. Further assurance on privacy was that privacy would be strictly protected according to ethical considerations in any given academic research while also ensuring that the participants involved in the study consented to participate voluntarily. According to Burton and Steane (2004), to build researcher's credibility on a research study and to balance multiple stakeholders' demands that might be divergent during a given research study, it is necessary to devise research processes that should include ethical protocol.

Cross-sectional research approach was used. Cross-sectional design is an observational research design which is usually used when populations are being studied (Maninder, 2016). One of the advantages of this design is that it is relatively faster and less expensive compared to other study designs. The study used KII, EO and FGD during the collection of data on qualitative information. The use of qualitative approaches gave an insight into the participants' ideas, opinions and experiences on the problems that were being investigated. When several data collection methods are used in a research study, researchers are able to get a holistic understanding of a complex study situation (Ali and Yusof, 2011). Climate change and pastoralism are complex situations and the use of observations, interviews and archives was therefore necessary to enable better understanding of the two complex situations which the study was investigating.

3.4 SAMPLING METHOD

Gaganpreet (2017), described sampling as a procedure or technique that could be used when systematically selecting relatively smaller number of representative from a population for the purpose of a given research study. Sampling techniques can be employed differently in different fields in a research fields.

Non-probability and probability samplings are the two main sampling procedures that are mostly used in research studies. The probability sampling is described as a sampling procedure where anyone in a given population of study stands a chance of being selected to participate in the research study. The non-probability sampling is a sampling procedure where there is no clear definition of a population of study in a given research study. The research used systematic sampling and non-probability sampling procedure (purposive random sampling) taking into consideration of the livelihood zones within Kajiado County.

3.5 SAMPLE SIZE DETERMINATION

Kumar (2011) gave a description of a sample as any examined subgroup of population that would be able to give the characteristics of a study population. According to Sekaran and Bougie 2016, appropriate sample size for a survey-based study could be determined by level of confidence, percentage of prevalence of the variable that is of interest in the study and margin of error that would be acceptable. According to Biswas and Charan, 2013, cross-sectional research is undertaken where estimation of population prevalence is required.

The County has 4 livelihood zones that includes mixed farming system, marginal mixed farming system, agro-pastoral system and pastoral system (CIDP, 2013). Most of the pastoral activities are practiced in Kajiado West, East and Central that fall under pastoral zone. Kajiado South falls under agro-pastoral zone while Kajiado North is under mixed farming zone but with limited pastoral activity in some specified areas (Area between Erankau and Oloolokitikoshi).

Each of the five sub counties within the County has administratively five wards giving a total of twenty-five wards in the whole of the County. All the 5 sub counties were first purposively (non-probability sampling) selected with the presumption that pastoralism is being practiced in the whole of the County. The population within the five sub counties constituted the sampling frame. Based on the livelihood zones, purposive selection of wards within the five sub counties was done to aid in the qualitative data collection. The focus discussion groups were then systematically selected within the selected wards. The selection was done with the guidance from the local community and opinion leaders.

The choice of purposive sampling procedure was informed by the opinion that samples collected from within the sub counties and wards would be appropriate and would answer the research questions and objectives of the study adequately well. According to Michael (2011), non-probability sampling procedure is commonly preferred because it is relatively less expensive and has a quicker implementation compared to other procedures.

3.6 DATA COLLECTION

Ghuri and Gronhouag (2005) described research methodology as a data collection method that is systematic, focused and orderly purposely to get relevant information to assist in the solution of research questions and objectives. Data can be described as facts about study areas that are collected during a research study. Two main categories of data include secondary and primary data. The primary data is information that has been directly collected from the respondents or it is information that a researcher might have had first-hand experience with during data

collection. The secondary data on the other hand is information usually collected from books, publications, reviewed literature and existing records.

3.6.1 Primary Data

The primary data collected was mainly on climate variables (temperature and rainfall), livestock disease incidence, livestock disease intervention, livestock disease prevalence, adaptation strategies, challenges and opportunities.

3.6.1.1 Primary Data Collection

The qualitative data collection methods used during the data collection included EO, KII and FGD. Published participatory data collection methods that included listing, simple ranking and pairwise ranking and probing aided in the collection of primary data on the current adaptation strategies, livestock disease prevalence and challenges and opportunities. The use of participatory research methodology during the data collection enabled the utilization of each of the group's distinct and clearly marked discipline for unique comparative advantages during the interviews and discussions. The discussions and interviews created opportunity for closer interactions with the community, opinion leaders and experts thus getting their impression and opinion on climate change as it was affecting pastoralism in the County.

The methodologies used enabled participation by research participants (population of study, researcher, leaders and other stakeholders) in the study and gave them an opportunity to identify problems that were affecting pastoralism as a livelihood support system in the County as a result of climate change. The participants were also able suggest solutions that could be applied when addressing the problems affecting pastoralism and are associated with the changing climate. Therefore, the sources of knowledge for the study included the researcher and his assistants, Maasai pastoralists, the government technical departments and organizations in Kajiado.

3.6.1.1.1 Focus Group Discussions

The study conducted 10 FGDs were conducted in the five sub counties of the County with each sub county having 2 wards. This ensured fair distribution and representation of the sub counties within the County. The number of people per group was between 6 and 16. The participants were mobilized and selected through assistance and support from the village elders, ward administrators and chiefs and they were people who had lived within these wards for several years and were conversant with Maasai culture and their major production system

(pastoralism). The selection of the participants for FGDs took in consideration gender inclusivity where both men and women were selected. The youth and the disabled were also given consideration in the selection.

The recruited participants were those who understood the Maasai language and were therefore conversant with the situation within the locality but for the purposes of triangulation of the information on livestock diseases that might have been identified by the participants during the discussions, veterinary personnel from within these localities (wards) were also recruited to be part of the participants to assist during focus group discussions at the same time to serve as key informants during the study. Recruitment was done according to FGD guidelines although in some groups, participants were slightly higher than the number recommended by the guidelines but this had no major effect on the outcomes of the discussions. Dilshad and Latif (2013), describe composition of focus group discussion to be between 6-12 participants with these individuals having certain characteristics and having been brought together purposely to explore perceptions, ideas, attitudes and feelings they might have about a given topic.

The discussions were held in homesteads, community's makeshift structures of worship or schools that had been identified by chiefs or village elders through consultation with research team. The FDGs were carried out through semi-structured interview schedules using open-ended questions (Annex2). The aim of the questions was to elicit responses and thereby generate reasonable amount of discussion and opinions among participants. The questions used during the FGDs guided the discussions based on the study objectives. The distribution and location of FDGs are as shown on Figure 4 and Annex 3. The FGDs were conducted between June 2016 and August 2019.

Data collection was on climate variables (rainfall and temperatures), livestock disease incidence, livestock disease interventions, livestock disease prevalence, climate change adaptation measures, challenges and opportunities. Collection of data on adaptation strategies, livestock disease prevalence, challenges and opportunities were aided by the published participatory data collection methods including listing, simple ranking, pairwise ranking and probing. According to Catley *et al.* 2012, simple ranking and pairwise ranking and probing are structured ranking methods usually used to prioritize listed factors with the aim of making decisions through consensus. Simple ranking is one of the simplest evaluation methods and it was used to rank adaptation strategies and livestock diseases. During the ranking there was simple establishment of the relationship among the climate change adaptation strategies and livestock diseases by giving a ranking number. The pairwise ranking, also described as

preference ranking was then further used to rank the strategies and diseases in pairs. The rankings on strategies and diseases from simple ranking and pairwise ranking and probing were computed into scores.

The interviews started with identification and listing of common adaptation strategies being applied during drought or rains/floods by the pastoralists and where necessary there was probing to establish if the strategy had been correctly identified. Likewise, pastoralists identified and listed livestock diseases that were prevalently affecting cattle, sheep and goats in relation to the changing climatic conditions. In identification of some these diseases that constrain livestock productivity, pastoralists applied the usage of local names that the diseases were being identified with in the County. Where the pastoralists could only identify the disease using syndromes rather than specific name of the disease, probing was done to get clarity on the identified disease but final validation of the actual disease in reference was later done through the assistance of technical staff from veterinary office within the County coupled with other sources of literature with relevancy on such diseases.

Listing of the strategies and livestock diseases was then followed by simple ranking of the strategies and diseases according to how their importance or commonness was perceived. Simple ranking was performed for the listed adaptation measures during drought and flooding or rains and livestock diseases that were impacting on the livelihoods of the pastoralists for the purposes of prioritization. Simple ranking was done to simply establish any relationship among the strategies and diseases through assignment of a ranking number. A matrix box for simple ranking was created for results from each of the sub counties. Simple ranking was followed by pairwise ranking and probing where ranking was done based on perception on the commonness or importance of the strategy or disease.

Pairwise ranking and probing followed simple ranking to characterize the strategies or diseases. During the pairwise ranking, box matrices were drawn and within the matrix, each box was representing an intersection of two diseases or two strategies. From the diseases or strategies listed, the determination of importance or commonness of the strategy or disease was done through consensus and the strategy or disease marked in the box appropriately. Where two strategies or diseases had similar appearances, the box within which the two strategies or diseases were compared was given consideration and strategy or disease that was appearing within that box was ranked highly. After filling all the boxes within the matrix, the ranking was done for strategies or diseases depending on how many times they were appearing within the matrix box.

The participants also listed challenges that were affecting pastoralism as a production system and were as a result of climate change and variability. They further listed the opportunities available for exploitation in addressing challenges climatic changes. They also gave their proposal on interventions that they felt could address the challenges. This formed the framework through which thematic analysis was done.

For data on climate variables, livestock disease incidence and interventions, the guiding questions for the focus group discussions were based on climate change awareness, parameters showing that climate has changed, the duration over which climate has changed, livestock disease incidence and livestock disease interventions in place to control livestock diseases. Figure 4 shows Focus Group Discussion sites.

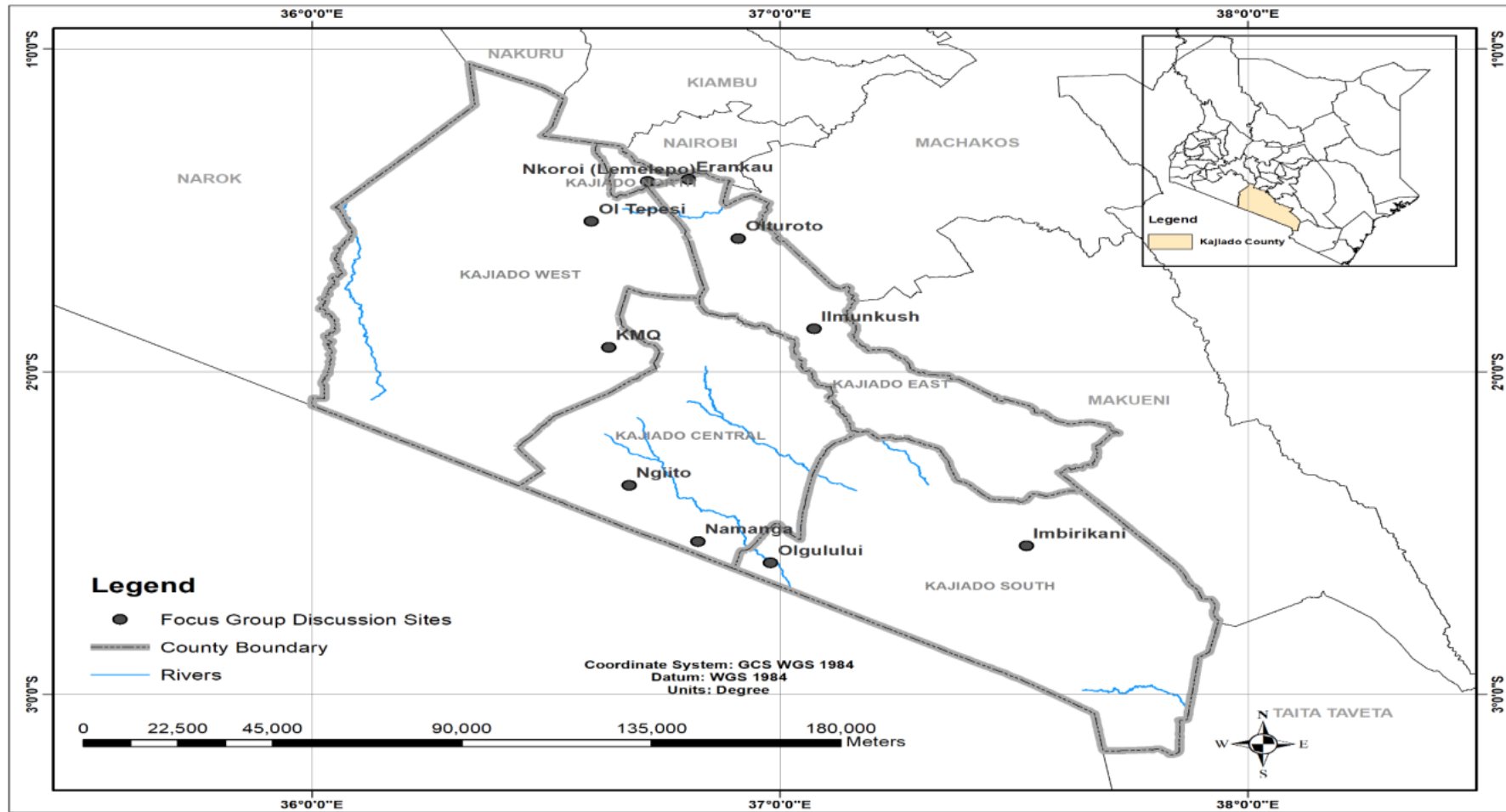


Figure 4 : Focus Group Discussion Sites

3.6.1.1.2 Key Informant Interviews (KIIs)

Key informant interview is usually conducted purposely to collect information from people assumed to have first-hand information about the community of a study area. It is a qualitative in-depth interview with people with deeper knowledge on what is going on in the community and such people could include community leaders, professionals or residents themselves. The interviews were conducted with chiefs, opinion leaders, village elders and staff from a Non-Governmental Organization (NGO) and Veterinary Department within the County. The interviews were face-to-face.

Twenty-five KIIs were conducted, six of which were conducted with the community's opinion leaders, five with village elders, six with chiefs, six with staff from Veterinary Department and two with staff from an NGO within the County. The selection of the informants was through the assistance of the chiefs and village elders with guidance of the research team. The interviews were guided by open-ended questions (Annex 2). There was learning and exchange of knowledge during the interviews. The informants were able to learn from the researcher and researcher from the informants. Data collected was on climate variables, livestock disease incidence, livestock disease interventions, livestock disease prevalence, climate change adaptation measures, challenges arising from climatic changes and any opportunities for exploitation when addressing the challenges of the changing climate. The interviews were conducted between June 2016 and August 2019.

3.6.1.1.3 Expert Opinion Interviews (EO)

An expert is a person with a specialized knowledge in relation to professional field of specialization such as technical or social field (Bogner *et al.* 2009). The choice of an expert would depend on the research area and the research questions that might be focusing on process or technical related knowledge. Twelve expert opinion interviews were conducted with experts drawn from technical departments within the County with the research questions focusing on technical-related knowledge. The selection of the experts was based on the technical relevancy of the selected departments in relation to the study. One expert each was interviewed from Meteorological Department and NDMA, two from agriculture department and eight from veterinary department and livestock Production department. Data collected was on climate variables, livestock disease incidence, livestock disease interventions, livestock disease prevalence, climate change adaptation measures, challenges and any opportunities. The EO interviews took place during the same period as FDGs and KIIs.

3.6.1 Secondary Data

Data on temperature and rainfall was from department of meteorological services for a period spanning over 30 years (1973-2015) while data on livestock disease incidence and corresponding interventions measures were collected from veterinary department in Kajiado. The data on rainfall and temperature comprised of monthly recorded figures that were then computed to give average annual values. Data on trend on climate and livestock occurrence was validated through the community' perception on trend in climate and disease occurrence from the results on data from Meteorological Services and Veterinary Services. Other information on secondary data was obtained from published research papers or journals, books and other online publications.

3.7 DATA MANAGEMENT AND ANALYSIS

3.7.1 Primary Data Analysis

Qualitative data collected on climate variables (rainfall and temperature), livestock disease incidence and interventions were recorded in notebooks and then entered into a database. The validation of the primary data was done through the reported results from the community perception on trend in climate and disease occurrence and analyzed data from Meteorological Services and Veterinary Services. The data were then analysed through content analysis, appropriate conclusions drawn based on the questions and objectives of the study. The results were reported as community's perception on trend on climate and livestock disease incidence and livestock disease interventions.

The rankings on strategies and livestock diseases prevalence from simple ranking and pairwise ranking and probing were computed into scores. The ranking scores obtained on adaptation strategies and livestock disease prevalence were analysed using Kruskal-Wallis h test to determine whether the median ranks for scores for the strategies and diseases had any significant difference from zero. A significant difference between two groups or two points was determined by measuring the difference between the groups with the statistical assumption that the probability of obtaining the difference by chance is very small (should be less than 5%). The difference was assumed to be due to the experimental treatment or manipulation. A z-score or a standard score gave an indication on how the data point was far from the mean. This was a further indication of how below or above the mean of population, the standard deviation was in comparison to the raw score. Kruskal-Wallis H test also described as one-way ANOVA is a score ranking test named after William Kruskal and W. Allen Wallis who

used the test for comparison of independent samples with different or equal sizes. The identified adaptations, challenges and opportunities, formed the thematic areas for discussion with the participants to seek their knowledge, views, opinions or experiences on adaptations, challenges and opportunities. Thematic analysis was used to analyse data on challenges and opportunities. Thematic analysis is a common form of analysis within qualitative research that emphasizes, identifies, analyses and interprets themes within qualitative data. Thematic analysis put emphasis on identification, analysis and interpretation of the challenges and opportunities.

3.7.2 Secondary Data Analysis

3.7.2.1 Trend Analysis

For climate data analysis, the study period was divided into two: Period A (1970 to 1993) and Period B (1994 to 2015). For ease of analysis when using measures of central tendency and dispersion, the study chose the use of periods instead of time series. Extremes/outliers in the rainfall and temperature data were eliminated through the use of Quartile Range. The precise and clean statistics that was used for the analysis was got through the Interquartile Range (IQR). The analysed data gave the trend on rainfall and temperature. The data was first entered into SPSS version 20.0 then analyzed through inferential statistics and descriptive statistics. Computation of descriptive measures (mean, median and coefficient of variation) was done to determine the climate trend.

The measure of central tendency gave the idea of how the data was summarized using the mean, mode and median. To understand how diverse, the data was, measure of dispersion, specifically the interquartile range was used. Coefficient of variation that describes variability within a sample data in relationship to a population mean was got by dividing standard deviation by mean and then multiplying result by one hundred. Standard deviation is a measure of how group members differ in comparison to the group mean.

Analysis was further done to determine the differences in the mean values for temperature and rainfall between the two periods (A and B). Inferential statistical analysis was used through the use of unpaired t-test, with 5% level of significance for determination of the mean values. This was because where comparisons of means of two samples might be required, t-tests can be used. Therefore, the study used t-test to compare the means values of rainfall and temperature. There are two types of t-tests commonly used; unpaired and paired t-tests. In paired t-test, the test subjects are the same and in unpaired t-test, test subjects are distinctly different. The un-

paired t-test was used in comparing the mean for the rainfall and temperature for the two periods. While the rainfall was measured in millimeters, temperature was in degrees centigrade hence both samples were subjected to distinct tests. This was done to establish if there was significant variation in values between rainfall and temperature within the two periods. The calculation was done through excel sheet and the reported results were generated through the system. Presentation of results was through graphs and tables. Livestock disease incidence and intervention data was analyzed by computing descriptive statistical measures (mean and median). SPSS version 20 was used for computation. Presentation of results done through graphs.

3.8 CONCEPTUAL FRAMEWORK

The relationship between sustainability of pastoralism (the dependent variable) and climate change (independent variable) is explained through a conceptual framework shown on Figure 5. While climate variability is normal variation in climatic parameter from its long-term mean of a region and is generally attributed to natural causes, together with natural variability, human activities indirectly or directly attributes to climate change. Climate change is thus contributing immensely to climate variability. Sustainability of pastoralism will depend on the extent to which climate change impacts or challenges on the pastoral activities in the County. Changes in climate would cause variations in rainfall and temperature. The observed change or variability causes impacts that would then trigger response strategies. The degree of the variability in rainfall and temperature would determine how vulnerable the pastoralists would be to climate change. The extent of vulnerability would then determine sustainability of pastoralism as the pastoralists would be trying to respond to the impacts or challenges. The challenges or impacts would trigger implementation of adaptation strategies. The strategies combined with opportunities would reduce vulnerability pastoralists to climatic changes. Effectiveness of response strategies being implemented will depend on the challenges or impacts and the opportunities that are exploited for during implementation of the strategies. If the strategies and opportunities are effectively implemented, there could be reduction in climate change impacts or challenges on pastoralism with sustainable pastoralism as the end result.

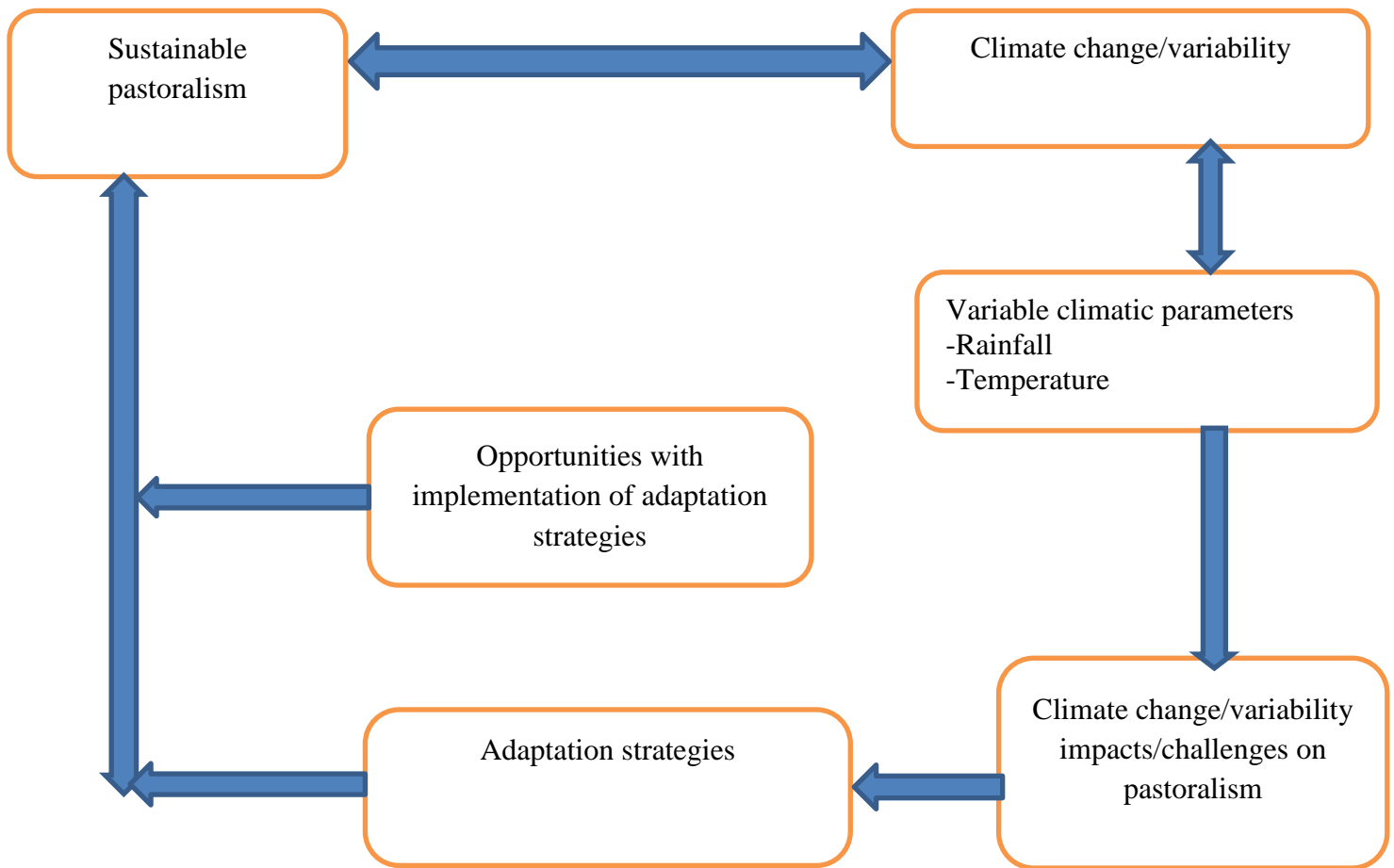


Figure 5: Conceptual Framework

CHAPTER FOUR

RESULTS AND DISCUSSIONS

The chapter provides details of results for each objective and discussions on results for each of the objectives.

4.1 TRENDS IN CLIMATE AND LIVESTOCK DISEASE OCCURRENCE IN KAJIADO COUNTY

4.1.1 INTRODUCTION

Rainfall and temperature are important climatic factors that have great influence on pastoralism as production system for they do not only affect livestock production but they also affect the incidence and distribution of livestock diseases. Understanding the trends, especially long-term trends, in rainfall and temperature might be critical in any pastoralism and climate change related research studies. Pastoralism is dependent on both rainfall and temperature due to its dependence on natural resources (water, pasture). Proper management of pastoral activities and livestock diseases and planning in pastoral areas would be much improved with appropriate knowledge on trends on climate parameters under changing climatic conditions. Changes in climate threatens livestock productivity as the impacts affects pasture quantity and quality, livestock diseases, availability of water and biodiversity. Production of pasture would be affected by both the rainfall pattern and temperature ranges by the fact variation in rainfall patterns and temperature ranges would determine pasture quality and quantity with lower rainfall amounts and drier periods resulting in inadequacy of pasture and uncertainty on availability of pasture.

Changing climate has evidently been shown to have affected and would continue affecting incidence, distribution and prevalence of animal diseases (Gale *et al.* 2009). Spatio-temporal scales of climate variables such as rainfall and temperature have also been shown to have definite roles in climatic changes that affect the incidence of livestock diseases (Bett *et al.* 2017). However, occurrence of livestock diseases is usually over shorter geographical and temporal periods with analyses that link livestock disease occurrence and climate change having many specification biases and uncertainties. Farming practice, land use, the disease causing-pathogen, vectors that transmit the diseases, environmental changes and new microenvironments and microclimates are some of the factors that would affect occurrence and distribution of diseases of livestock. Therefore, with climate change these factors should be

given some consideration where livestock disease occurrence and distribution is being investigated (Gale *et al.* 2009).

Research conducted through Kimaru *et al.* 2017 among pastoralists in Northern Tanzania on vector-borne diseases of cattle and climate change, found that African animal trypanosomiasis and east coast fever were among the highly ranked diseases of cattle by the pastoralists of Northern Tanzania with the occurrence being linked to specified seasons. However, vector occurrence especially *Glossina* and *Rhipicephalus species* had no association with any specific season. There was a general acknowledgement among the pastoralists that changes have occurred in environment, rainfall pattern and temperature over a period spanning thirty years. They also identified some decrease although not very significant in *R. appendiculatus* and ECF occurrence during this period.

This section looked at the trend in climate variables (rainfall and temperature) and how the trend was affecting livestock disease occurrence in Kajiado County. The objective was to analyse the trends in climate and livestock disease occurrence in the County. Pastoralism as a form of livestock production system is defined by the number of livestock kept by the individual pastoralists. Increased incidences of livestock diseases would lead to livestock mortalities and poor livestock performance with resultant reduction in the number of livestock and uncertainty in sustainable pastoralism. There is also collapse of livestock markets leading to increment on vulnerability of the pastoralists. The major findings were that there was statistical evidence to support climate variability but no evidence to support climate change. Major diseases reported to have occurred on farms in the County included helminthiasis, trypanosomiasis, anaplasmosis, east coast fever and pneumonia with helminthiasis and trypanosomiasis having higher incidences of occurrence.

4.1.2 RESULTS

4.1.2.1 The community perception of trend in climate variables

Community's perception was that rainfall has become low and unpredictable, erratic and of shorter duration while temperatures were occasionally becoming very high or too low. Dry seasons or droughts had become unusually prolonged. Drought is increasingly becoming more severe over period of time. There was also the perception that water sources were drying up, vegetation cover was being lost and pasture was becoming scarce due to the observed climatic changes. The changes in climate have reportedly interfered with the community's cultural calendar of climate predictions through their indigenous knowledge. The community's

perception on trend on climate variables was validated through the analyzed secondary data from Meteorological services

4.1.2.2 Trend in climate from archived Meteorological data

Table 1 below shows the results from the analyzed climate data (Rainfall and temperature). The result showed that average annual amount of rainfall for period A (1970-1993) was 793.70 mm while that for period B (1994-2015) was 765.17 mm. The validation done between the two values (A and B) established that that the two means were not significantly different. The minimum recorded average annual rainfall amount for period A was 438 mm while for period B, the minimum recorded average annual rainfall amount was 4.5 mm. The maximum recorded average annual rainfall in period A was 1,107 mm while for period B the maximum recorded average annual rainfall was 1,174 mm. There was variability in rainfall which was shown by the increment on coefficient of variation from 21.6% (period A) to 32.02% (period B)-Table 1.

The average annual temperature for period A was 19.6⁰C while for period B, it was 19.8⁰C. The validation done between the two values (A and B) established that that the two means were not significantly different. The minimum recorded average annual temperature was 18.4⁰C for period A and 16.4⁰C for period B while maximum recorded average annual temperature was 20.4⁰C for period A and 20.6⁰C for period B. There was variability in temperature which was shown by the increment on coefficient of variation from 2.6% (period A) to 4.04% (period B)-Table 1.

Table 1: Descriptive summary of average amount of rainfall (mm) and temperature ($^{\circ}\text{C}$) between 1970 and 2015 in Kajiado County

| Type of climatic parameter | Period A (1970- 1993) | | | | | Period B (1994-2015) | | | | |
|---------------------------------------|------------------------------|--------|---------|---------|-------|-----------------------------|--------|---------|---------|-------|
| | Mean | SD | Minimum | Maximum | CV% | Mean | SD | Minimum | Maximum | CV% |
| Rainfall amounts mm per annum (n= 21) | 793.70 | 171.36 | 438.23 | 1107.43 | 21.60 | 765.17 | 245.01 | 4.50 | 1174.13 | 32.02 |
| Average annual temperatures (n=21) | 19.60 | 0.50 | 18.40 | 20.40 | 2.60 | 19.80 | 0.80 | 16.40 | 20.60 | 4.04 |

Table 2 shows the results from inferential analysis which was done through un-paired t-test to determine differences on mean in temperature and rainfall between the two periods (A and B) with the level of significance being at 5%. The mean annual rainfall did not show a very significant difference during the two periods (A and B) since averagely the mean for the two periods was within the range of 700mm of rainfall. Likewise, the mean annual temperature values for the two periods were not significantly different as the values for the two periods were within the range of 19.0°C.

Table 2: Comparison of average annual temperature and rainfall, Kajiado: 1970-2015

| Description of climatic parameters | Period A | Period B | p-value |
|------------------------------------|----------|----------|---------|
| Average amount of rainfall (mm) | 793.70 | 765.17 | 0.65 |
| Average annual temperatures (°C) | 19.6 | 19.8 | 0.20 |

The variability in rainfall distribution was further demonstrated through the time series where means of the average annual rainfall figures between 1970 and 2015 were plotted as shown on Figure 6. The minimum average annual rainfall indicated in Table 1 was recorded during the year 2006 as also shown on Figure 6.

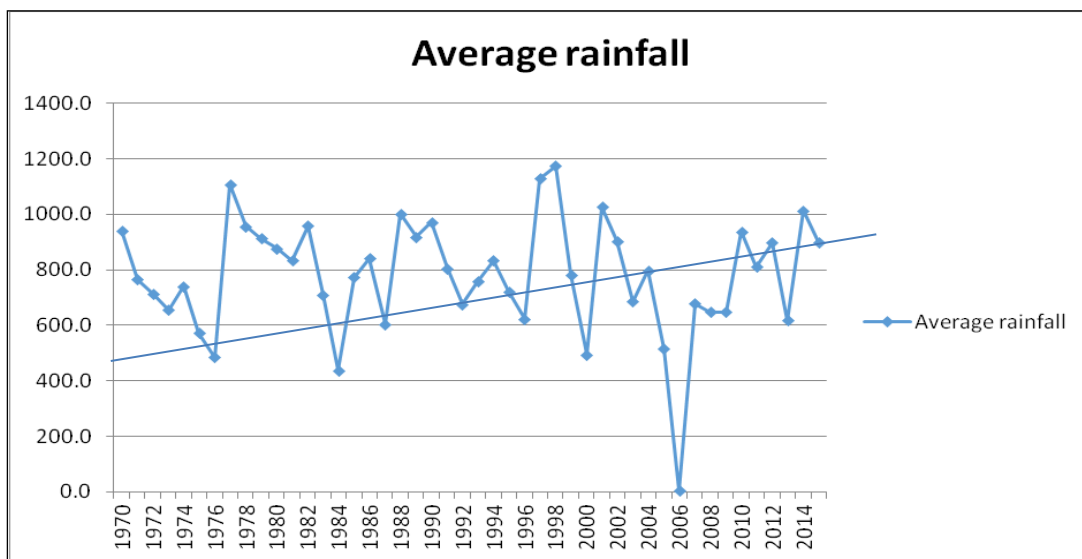


Figure 6: Average annual rainfall variability in Kajiado County from 1970 to 2015

4.1.2.3 The community perception on trend in livestock disease occurrence

According to the pastoralists, there were increased incidences of livestock diseases. The increase is being associated with the observed changes in climate in the County. Livestock diseases reportedly affecting their livestock in the County included FMD, ECF, contagious caprine pleuropneumonia, anthrax, black quarter, contagious bovine pleuropneumonia, *pestes*

des petit ruminants, sheep and goat pox disease, rift valley fever disease and lumpy skin disease.

4.1.2.4 Trend on livestock disease occurrence from Veterinary office records

The incidence or occurrence refers to the proportion or rate of livestock that developed a disease condition during a particular time period. Figure 7 shows the trend in livestock disease occurrence. The following livestock diseases reportedly occurred on farms within the County according records from the Veterinary office: helminthiasis, trypanosomiasis, anaplasmosis, East Coast fever (ECF) and pneumonia. Helminthiasis was shown to have occurrence of about 5,000 cases, followed by trypanosomiasis at 3,000 cases. Other diseases reported to had occurred on the farms included sheep and goat pox, foot and mouth disease, anthrax, blackquarter, rift valley fever disease, PPR, ('goat plague'), CBPP, CCPP and lumpy skin disease.

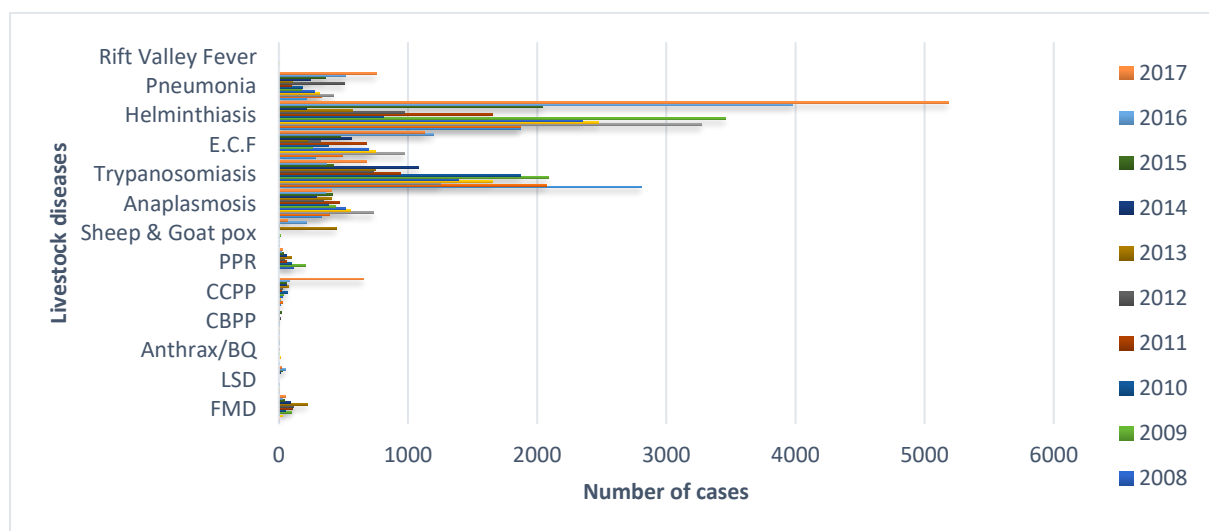


Figure 7: Trend in Livestock disease occurrence

4.1.2.5 Livestock Disease Intervention

Figure 8 shows livestock disease intervention. Analysis of livestock disease interventions showed that the diseases such as sheep and goat pox, rift valley fever disease, blackquarter, anthrax, CBPP, CCPP, pestes des petitis ruminants and foot and mouth disease had low occurrence following the interventions. Vaccination was indicated as the main intervention being undertaken by the County Government of Kajiado.

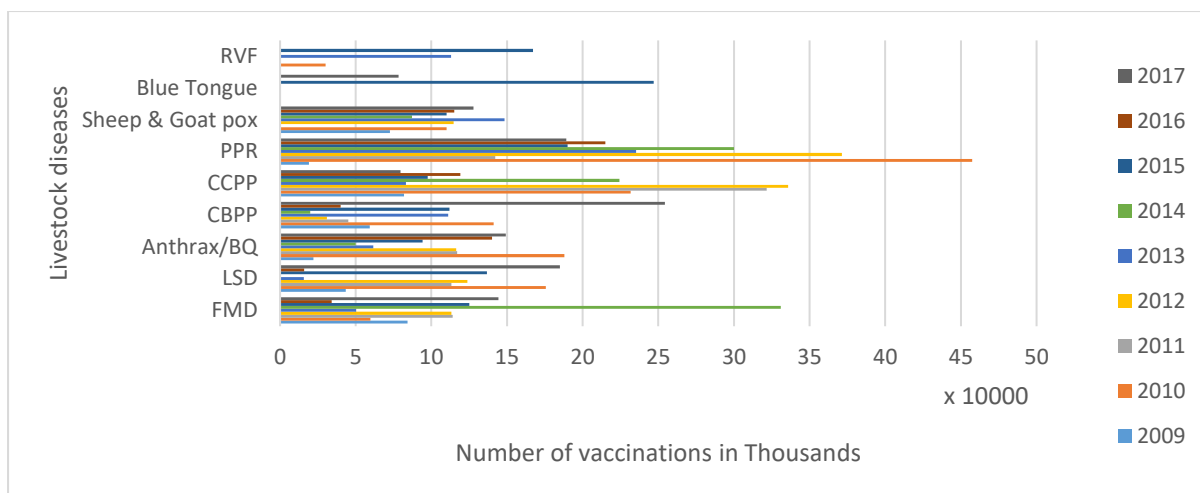


Figure 8: Livestock disease intervention trend in Kajiado County

4.1.3 DISCUSSIONS

From the findings, there was no evidence to show that average annual temperature and rainfall had changed significantly between these periods of study ($P > 0.05$) but there was an increase in variability in average amounts of rainfall and temperature as shown by an increase in coefficient of variation from 21.6% (1970 to 1993) to 32.02% (1994 to 2015) for the rainfall and an increase in coefficient of variation from 2.6% (1970 to 1993) to 4.04% (1994 to 2015) for the temperature. From the community's perspective, climate variability was being observed through unpredictable rainfall, prolonged droughts and high temperatures. The unpredictability here meant that rainfall was not coming when expected or when it came, it was either too little or it was coming in terms of flash floods. These climatic changes led to diminishing sources of water, inadequate pasture, loss of biodiversity, emergence of or increased livestock diseases, massive livestock deaths and poor livestock productivity.

There were reported livestock deaths either through livestock diseases or starvation but the distinction between the deaths arising from diseases and starvation could only be possible through the postmortem of the dead animals. The veterinary staff who were part of the FGDs, KIIs and EO assisted in triangulation of such reported deaths. Although the actual number or the percentage of livestock deaths caused by diseases and those caused by other climate change-related impacts such as starvation could not be established as this was beyond the scope of the study

Reportedly there were increment on the livestock disease incidence that was being associated with the climate variability in the County. Helminthiasis, trypanosomiasis, anaplasmosis, east

coast fever, and pneumonia were reported to have occurred on farms according to records obtained from government veterinary office with trypanosomiasis and helminthiasis reportedly occurring at high frequency compared to the rest of the diseases. Kimaru *et al.* 2017 conducted a research study among pastoralists of Northern Tanzania on climatic changes and diseases of cattle caused by vectors. The results showed that incidence of livestock diseases followed the same pattern as that of this study where it was found that trypanosomiasis and ECF were among the diseases with high incidence. The increment on disease incidence is already adversely impacting on pastoralism within the County as established by the study. UNFCCC (2007) and WSPA (2012) had reported that climate change was expected to adversely affect in ASALs for both milk and meat producing animals where the production systems are vital for nutrition and livelihoods.

The year 2006 had the least recorded rainfall figures in Kajiado with the most reported livestock diseases being helminthiasis, trypanosomiasis and tick borne diseases including ECF and anaplasmosis while the diseases which were reported to have occurred at higher frequencies during the El Nino year (2017) included helminthiasis, east coast fever, pneumonia and trypanosomiasis. The occurrence of helminthiasis appeared to have been highest in 2017. The occurrence of these diseases during drought period (2006) and El Nino period (2017) did not seem to have direct relationship with variability in rainfall and temperature since they were equally reported during drought and during floods. This seems to be in conformity with the observations made by Bett, *et al.* (2017) that investigation on climate change and disease occurrence would show a lot of uncertainties and specification biases. Some of the livestock diseases that were considered by the pastoralists to be of economic importance to livestock production system in Kajiado but were reportedly having low occurrence due to vaccination having been undertaken by the County Government of Kajiado as an intervention included RVF, CBPP, CCPP, Blackquarter/Anthrax, FMD, PPR and Sheep and Goat Pox.

4.2 CHALLENGES AND OPPORTUNITIES AVAILABLE FOR IMPLEMENTATION TO SUSTAIN PASTORALISM

4.2.1 INTRODUCTION

Variability in global climate has raised new challenges for the pastoral production systems within Africa and other areas around the world. This making adoption of livestock production practices that enhance the resilience and productivity of pastoral production systems very challenging. Climate change/variability has become a new challenge for the traditional pastoral production system due to the effects on livestock production. Therefore, there is need for enhanced support to the pastoralists to enable them address challenges that are emerging as a result of changes in climate.

Challenges that are being associated with changes in climate could be addressed by scaling up and reprioritizing adaptation strategies that would be able to sustain pastoralism. The current emerging challenges for the pastoralists include climate change/variability, increase in human population and subdivision and sale of land for human settlement and industrial development thus significantly reducing the practice of pastoralism while traditional challenges include low pasture productivity, inter-community, livestock/wildlife and human/wildlife conflicts associated with migration, low livestock prices, lack of permanent residence during migration, among others.

Building the capacity of the pastoral communities by designing and implementing climate change programmes could enable pastoralists to adopt strategies that could make them to adequately adapt to impacts of climate variability and change with the aim of reducing challenges being encountered through their traditional pastoral production system under the rapidly changing climate. Under this section, the objective was to identify the challenges that have been observed to have resulted from climate variability and change and any opportunity that could be exploited and implemented for sustainability of pastoralism in Kajiado County.

4.2.2 RESULTS

4.2.2.1 Challenges associated with climate variability

Table 3 shows the challenges identified by the pastoralists to be affecting the pastoralism as a production system in Kajiado and the suggested interventions to address the challenges. These challenges included animal deaths, increment on disease occurrence, high expenditure associated with migration, conflicts (inter-community, livestock/wildlife and human/wildlife

conflicts), unavailability of veterinary vaccines and drugs for prevention and control of livestock diseases, expensive veterinary drugs and vaccines, inadequate technical staff and unavailability of water and water sources.

Other production challenges included unavailability of hay during dry periods, high cost and low quality hay, low livestock prices, unacceptability of destocking by the pastoralists due to cultural instinct, insecurity for both animals and human beings during grazing within the game parks, lack of man power (herders) to migrate and herd the migrated livestock, no permanent residence (sleeping in the cold) during migration, wildlife preying on livestock as the livestock grazing or passing through the park, destruction of water sources such as pans and dams by wildlife especially by elephants, inadequate extension, low pasture productivity and low quality hay and other commercial animal feeds and supplements.

Table 3: Challenges associated with Climate variability

| Challenge | Suggested intervention |
|--|---|
| Increase in incidences of animal diseases and pests | -Effective animal disease control services -Provision of extension services on disease control -Adequate technical staff |
| Massive livestock deaths due to diseases and lack of pasture/feeds | -Provision of hay during drought -Effective animal disease control services -Pasture production and conservation -Construction of hay storage facilities -Effective livestock extension services to advice on livestock diseases and pasture growing and conservation -Introduction of livestock insurance scheme for compensation for livestock lost due to impacts of climatic changes |
| Long distance trekking when searching for pasture and water | -Water tankering during drought -Provision of hay during drought -Pasture production and conservation -Construction of hay storage facilities -Stoppage of subdivision of group ranches |
| High expenditure associated with migration | -Provision of hay during drought -Pasture production and conservation -Construction of hay storage facilities |
| Unavailable and expensive veterinary medicines and vaccines and low technical staff levels | -Provision of subsidized veterinary vaccines and drugs -Recruitment and deployment adequate technical personnel |
| Unavailability of water and water sources | -Water tankering during drought -Construction of boreholes, water pans and dams -Harvesting of water during rain through roof catchments using water tanks -Channelling run-off waters to dams and water pans for use during drought |

| | |
|--|---|
| Low pasture productivity | -Increase pasture productivity and conservation -Provision of pasture seeds, pasture planting equipment and hay harvesting equipment to improve on the pasture production and conservation |
| Unavailability of hay, low quality and expensive hay | -Provision of standardized and subsidized hay -Increase pasture production and conservation -Construction of hay storage facilities |
| Conflicts (inter-community, livestock/wildlife and human/wildlife conflicts) | -Minimize migration through increment of pasture productivity and conservation and provision of standardized and subsidized hay |
| Low quality and non-standardized commercial animal feeds | -Buy feeds from designated animal feed supply outlets -Provision quality and subsidized animal feeds |
| No permanent residence during migration | -Minimize migration through increment of pasture productivity and conservation and provision of standardized and subsidized hay |
| Culturally not acceptable to most pastoralists. | -Acceptance of destocking keeping herds that could be supported by the available land -sell part of the herd during drought and restock during the rains |
| Inadequate technical staff | -Recruitment and deployment of technical staff |
| Lack of man power (herders) to migrate and herd the migrated livestock | -Minimize migration through increment of pasture productivity and conservation and provision of standardized and subsidized hay |
| Wildlife predating on livestock and destruction of water sources such as pans and dams by wildlife | -Minimize migration through increment of pasture productivity and conservation and provision of standardized and subsidized hay |
| Insecurity for both animals and human beings when animals are being grazed within the game parks, | -Minimize migration through increment of pasture productivity and conservation and provision of standardized and subsidized hay |
| Low livestock prices due to poor livestock body conditions especially during drought | -Provision of marketing infrastructure for accessibility of market for livestock before drought period |

4.2.2.2 The prevalence of livestock diseases

Livestock disease prevalence refers to proportion of livestock that had a disease condition at or during a point in time.

4.2.2.2.1 Prevalent diseases of Cattle

Simple ranking and pairwise ranking and probing with the pastoralists gave various scores for the various prevalent diseases of cattle. The results are shown on Annexes 8 and 9. The results through the analysis by Kruskal-Wallis h test for cattle diseases are shown on Table 4. The prevalent livestock diseases that were posing a challenge to the cattle production in the County included east coast fever, lumpy skin disease, anaplasmosis, babesiosis, black quarter,

anthrax, contagious bovine pleuropneumonia, foot and mouth disease, heartwater, helminthiosis, mastitis, pneumonia and trypanosomiasis.

Table 4: Prevalent livestock diseases of cattle that affect livestock production under a pastoral production system in Kajiado

| Disease | Median | Average rank | z-score |
|-----------------------------------|---------------|---------------------|----------------|
| Black Quarter/Anthrax | 0.21 | 50.8 | 2.71 |
| Foot and Mouth Disease | 0.25 | 50.8 | 2.71 |
| East Coast Fever | 0.14 | 45.5 | 2.01 |
| Lumpy Skin Disease | 0.16 | 34.5 | 0.53 |
| Anaplasmosis | 0.05 | 32.8 | 0.31 |
| Helminthiosis | 0.07 | 30.6 | 0.01 |
| Contagious Bovine Pleuropneumonia | 0.00 | 25.2 | -0.71 |
| Babesiosis | 0.03 | 24.0 | -0.87 |
| Mastitis | 0.00 | 20.0 | -1.40 |
| Heartwater | 0.00 | 18.9 | -1.55 |
| Pneumonia | 0.00 | 18.9 | -1.55 |
| Trypanosomiasis | 0.00 | 14.0 | -2.21 |

H = 31.98 (adjusted for ties) with 11 df, Probability > 31.98 = 0.0008

4.2.2.2.2 Prevalent diseases of Sheep

The simple ranking and pairwise ranking and probing with the pastoralists done for diseases of sheep gave various scores for the various diseases that affect production. The results are shown on Annexes 10 and 11. Table 5 shows the analysis by Kruskal-Wallis h test on diseases that are affecting sheep. The prevalent livestock diseases that were posing a challenge to the sheep production in the County included pestes des petits ruminants, sheep pox, coenurosis, enterotoxaemia, rift valley fever, blue tongue, pneumonia and helminthiosis.

Table 5: Prevalent livestock diseases of sheep that affect livestock production under a pastoral production system in Kajiado

| Disease | Median | Average rank | z-score |
|----------------------------|---------------|---------------------|----------------|
| Pestes des Petit Ruminants | 0.33 | 35.3 | 2.22 |
| Coenurosis | 0.20 | 31.5 | 1.53 |
| Enterotoxaemia | 0.10 | 25.1 | 0.38 |
| Sheep and Goat Pox | 0.07 | 22.2 | -0.14 |
| Blue Tongue | 0.00 | 21.5 | -0.42 |
| Rift Valley Fever | 0.00 | 19.3 | -0.67 |
| Pneumonia | 0.00 | 18.2 | -0.87 |
| Helminthiosis | 0.00 | 12.5 | -1.90 |

H = 12.73 (adjusted for ties) with 7 df, Probability > 12.73 = 0.0791

4.2.2.2.3 Prevalent diseases of Goats

The simple ranking and pairwise ranking and probing with the pastoralists done for diseases of goats gave various scores for the various diseases that affect production. The results are shown on Annexes 12 and 13. Table 6 shows the analysis by Kruskal-Wallis h test on diseases that are affecting goats. The prevalent livestock diseases that were posing a challenge to the goat production in the County included contagious caprine pleuropneumonia, coenurosis, heartwater, rift valley fever, *pestes des petits ruminants*, pneumonia, blue tongue and helminthiosis respectively.

Table 6: Prevalent livestock diseases of goats that affect production under a pastoral production system in Kajiado

| Disease | Median | Average rank | z-score |
|------------------------------------|--------|--------------|---------|
| Contagious Caprine Pleuropneumonia | 0.33 | 31.3 | 2.21 |
| Coenurosis | 0.27 | 29.7 | 1.88 |
| Heartwater | 0.20 | 21.9 | 0.29 |
| Rift Valley Fever | 0.13 | 20.5 | 0.00 |
| Pestes des Petit Ruminants | 0.07 | 20.1 | -0.08 |
| Pneumonia | 0.00 | 16.4 | -0.84 |
| Blue Tongue | 0.00 | 13.6 | -1.41 |
| Helminthiosis | 0.00 | 10.5 | -2.04 |

H = 15.08 (adjusted for ties) with 7 df, Probability > 15.08 = 0.035

4.2.2.2.4 Opportunities for implementation for sustainability of pastoralism

Table 7 shows the identified opportunities that could be implemented to address impacts of climate variability for sustainable pastoralism in the County and consequent proposed implementation framework and alternatives for pastoralism. The opportunities included to culturally accept destocking as a remedy to the massive livestock loss during drought and diminishing grazing lands, investing on pasture production and conservation, introduction of feedlots, water harvesting during rainy season to ensure water availability during drought and use of livestock insurance scheme to insure livestock for anticipated loss during drought.

Other alternatives for pastoralism that were suggested included keeping fewer but high producing dairy animals (zero grazing) instead of large number of herds, livelihood diversifications such as crop farming, bee keeping, fish farming, etc. investing in housing developments, savings and other investments that are not climate-dependent using the proceeds accrued from sale of livestock and putting more emphasis on education instead of pastoralism. The introduction of dairy animals (zero grazing) was not meant to support sustainability of pastoralism but it was just among the options available to pastoralists who

are ready to opt out of pastoralism to a more viable and sustainable economic activity with the emerging challenges associated with climate change/variability

Table 7: Opportunities for implementation for sustainable pastoralism and Alternatives for pastoralism

| Opportunities identified | Proposed intervention |
|---|--|
| Investment on pasture production and conservation | -Pastoralists to provide land for pasture production -County government to construct hay storage facilities -County government to provide pasture seeds, ploughing and planting equipment, extension services on pasture planting and conservation |
| Culturally to accept destocking as a remedy to the massive livestock loss during drought and diminishing grazing land | Accepting destocking as a way to secure pastoral livelihoods |
| Introduction of feedlots | Use of special holding zones for animals |
| Water harvesting | Investment in water harvesting and construction of water pans and dams for run-off water during the rains |
| Introduction of livestock insurance scheme | Insurance of livestock |
| Alternatives for pastoralism | |
| Put more emphasis on education as a future investment instead of pastoralism | Increase enrolment of all school-going children in schools as an investment in education |
| Livelihood diversifications | -Crop farming -Bee Keeping as an alternative livelihood diversification -Fish farming |
| Keeping of Dairy animals | Keep fewer but high producing dairy animals -Introduce zero grazing (grade animals) that will occupy smaller area |
| Investing in savings and other developments | -Sell livestock before drought -Proceeds from the sale on other long term investments such as housing, etc. |

4.2.3 DISCUSSIONS

Several challenges were identified to be affecting pastoral production system in the County while several opportunities for implementation for sustainable pastoralism were also identified. The challenges were being experience across five sub counties but more prominently in the sub counties of Kajiado west, East, South and Central where major pastoral activities were being undertaken. Kajiado North which has sedentary livestock keeping system had comparatively different challenges from the rest of the four. Proposed interventions for addressing challenges in four sub counties (East, West, South and Central) were equally similarly but slightly different from those proposed by Kajiado North.

Most of the production challenges were being associated with migration of livestock. Livestock diseases were identified as major challenge to pastoralism as a production system in Kajiado. The diseases were affecting the major species, bovine and shoats that are being kept by the pastoralists. These diseases were reportedly affecting livestock during drought and flooding periods in the County. According to the Kruskal-Wallis h test, the diseases with highest prevalence included east Coast fever, foot and mouth disease and anthrax and black quarter, pestes des petits ruminants and contagious caprine pleuropneumonia ($Z > 1.96$). The prevalence of the diseases was associated with massive livestock deaths. Though through triangulation it was confirmed that not all the deaths were due to livestock diseases but some were due to lack of pasture and other animal feeds. Therefore, massive livestock deaths were being caused by livestock diseases, starvation due to scarcity of pasture or long distance trekking of animals when searching for pasture and water.

The high expenditure as a production challenge was due to the fact the pastoralists had to supplement the scarce pasture through buying of hay and other feed supplements, vaccinate and treat the animals, ferry water to the animals and pay for the herders and inter-community. The livestock/wildlife and human/wildlife conflicts were as a result of animals being moved through areas occupied by other communities or into the park where animals and human came into direct conflicts. There was also insecurity for both animals and human beings when the animals were passing through or being grazed within the game parks as wildlife preyed on both livestock and the herders. Lack of herders to migrate and herd the migrated livestock was due to the fact that most of the herders were of school-going age while lack of shelter for those moving with the livestock was because the animals were being moved to areas with no permanent abodes.

The challenges of unavailability of veterinary vaccines and drugs and expensive veterinary drugs and vaccines was as a result of pastoralists moving with their animals to search for pasture and water and exposure of the animals to new disease environment creating high demand for prevention and control of such diseases. Likewise, during flooding related disasters, there was increase on prevalence of livestock diseases raising the demand for livestock vaccines and drugs. While the vaccines and drugs were rarely available but even when available, they were unaffordable to most of the pastoralists. There was also inadequate technical staff to assist in the administration of the vaccines and drugs within the County and migration routes. Water was a major production challenge as water is a scarce commodity in

Kajiado due to the fact that most of the water sources were drying up during drought. Therefore, the pastoralists had to identify the water sources, buy the water and transport the same to where the animals had been migrated to which was very challenging and expensive. This challenge was exacerbated further the destruction of water sources such as pans and dams by wildlife more so by elephants that were also roaming about in search of water as the whole of the County including the parks was experiencing severe drought thus bring competition among humans, livestock and wildlife for the few available water sources.

Pasture and other animal feeds was also another production challenge as the hay and other animal feeds were unavailable and even if available were of low quality and expensive as the number of animals kept by the pastoralists was too large to be maintained by the commercial hay and the other animal feeds. Although livestock are kept by pastoralists in Kajiado mainly to provide income and as a source of food, livestock kept by individual pastoralist in terms of numbers also determines the social status of the individual in the society. This has made destocking 'not a cultural norm' making destocking not to be culturally acceptable among the pastoralists. The challenge of low livestock prices due to poor livestock body conditions especially during drought was as a result of the pastoralists selling their animals only when there was drought during which time the animal body condition had been affected by drought situation due to lack pasture and other animal feeds.

With climate variability, keeping large number of animals is posing a serious threat to pastoralism in Kajiado as pasture and water are diminishing under the changing climate calling for the pastoralists to start thinking of appropriate adaptation strategies for sustainability of pastoralism or other livelihood-support sources. Changes in climate have not only presented pastoralists of Kajiado with many production challenges but the changes have also presented the pastoralists with opportunities that they could be exploited for implementation in an effort to secure pastoralism as a major source of livelihood in the County. For water as a production challenge, pastoralists and the County government should invest in water harvesting during rainy season through use of water tanks for roof catchments and construction of water pans and dams for run-off water during the rains

Among the opportunities that were identified by the pastoralists and that could be exploited for implementation to safeguard pastoralism as a production system is investment on pasture production and conservation. The land for pasture production is still available in Kajiado despite the current land subdivisions going on due to demand for human settlement and

industrial developments. This required a concerted effort between the pastoralists and County government where the pastoralists have to provide land for pasture production and County government to construct hay storage facilities and to provide pasture seeds, ploughing and planting equipment and extension services on pasture planting and conservation. Another opportunity is the introduction of feedlots which are specially designed for fattening under intensive care before the animals are sold for slaughtering at enhanced prices. This will ensure that the perennial deaths of livestock especially cattle in County occasioned by climate variability is curtailed or minimized.

Water harvesting as an opportunity could be implemented by through the initiative of the pastoralists and the County government where there is water harvesting during rainy season through the use of water tanks for roof catchments and construction of water pans and dams for run-off water during the rainy seasons. The other opportunity that could be exploited by the pastoralists is destocking where only livestock that could be supported by available grazing land, pasture and feeds are kept to avoid the pressure being put on the climate-dependent natural resources that support pastoralism as a production system. The pastoralists could also insure their livestock through livestock insurance scheme for compensation in anticipation to livestock deaths occasioned by recurrent and prolonged droughts which are as result of climate variability in the County.

Alternative livelihoods available for the pastoralists include investing in housing developments, savings and other long term investments where the pastoralists should sell their livestock before drought and put the proceeds from the sale on these investments that are not climate-dependent as alternative sources of income. Crop farming is another alternative livelihood for the pastoralists where the pastoralists could use water from constructed boreholes, water dams and pans for crop irrigation. Other forms of livelihood diversification identified include bee keeping as the environment is suitable for bees and fish farming which is slowly gaining momentum in the County. The other alternative livelihood for the pastoralists in Kajiado is keeping fewer but high producing dairy animals instead of large number of herds. Kajiado has the potential to support high producing grade animals and pastoralists could introduce grade animals that will occupy smaller area but have high productivity as the grazing land is diminishing and pasture productivity is becoming poor due to the impacts of climate variability.

The dairy animals could be either free range or zero grazed. Introduction of dairy animals (zero grazing) does not support sustainability of pastoralism but it just among the options available to pastoralists to switch from pastoralism to a more viable and sustainable economic activity with the emerging challenges associated with climate change/variability. Investment in education through increasing enrolment of all school-going children in schools for the future development is another livelihood the pastoralists could pursue since the future of pastoralism is uncertain with the climate variability and diminishing grazing land. The suggested livelihood diversification such as crop farming, bee keeping, fish farming etc. are just alternative livelihood source for the pastoralists but these might mean also moving out of pastoralism or undertaking both but not as an adaptation strategy for pastoralism under a changing climate.

4.3 CURRENT CLIMATE CHANGE ADAPTATION STRATEGIES IN KAJIADO COUNTY

4.3.1 INTRODUCTION

According to Mwendwa and Giliba (2012), determination of changes in climate that might be due to human activities or natural changes might be challenging and would therefore present a difficult situation for developing countries especially when ascertaining climate change adaptation strategies. IPCC (2007) defined adaptation as any measure or initiative that is aimed at the reduction of human or natural systems' vulnerabilities when there are actual or expected effects of changes in climate. Adaptation can also be defined as adjustments that would be made by human or natural system as a response to expected or actual effect from a changing climate or normal climate effect. Mwendwa and Giliba (2012) further reported that although climatic changes are occurring globally, effects of these changes would be felt differently depending on the specific area where the change is occurring and the adaptation measures put in place to address the impacts.

The climatic changes coupled with the traditional livestock production systems where livestock are frequently moved to access water and pasture which are also climate-dependent are already putting pressure on the pastoral production systems in the ASALs. Therefore, there is need for appropriate climate change policies, strategies or approaches that could assist the pastoralists within the ASALs in the exploitation of new options and opportunities aimed at salvaging the pastoral livelihoods from the impacts of climatic changes. Resilience of vulnerable pastoralist's community should be built in the wake of climatic changes by ensuring that appropriate strategies are identified, prioritized and implemented accordingly. Under this section, the objective was to determine current adaptation strategies to climate change being implemented by the pastoralists in Kajiado.

4.3.2 RESULTS

4.3.2.1 Adaptation strategies being applied during drought related disasters by pastoralists in Kajiado

The adaptation strategies identified by the pastoralists and that were being commonly applied during drought related disasters included destocking, livestock vaccination and treatment, migration, purchase of commercial feeds and supplements, purchase of hay, survey of migration routes and water tankering. The ranking of the strategies by the participants through

simple ranking and pairwise ranking and probing were recorded as scores and the results are shown on Annexes 4 and 5. The average scores obtained during the rankings were analysed using Kruskal-Wallis h test to establish if the scores obtained were having any significant difference from zero. Results on Kruskal-Wallis h test are shown on Table 8.

Table 8: Adaptation strategies applied during drought related disasters by pastoralists in Kajiado

| Adaptation strategy applied by pastoralists | Median | Average Rank | z-score |
|--|---------------|---------------------|----------------|
| Migration | 0.27 | 24.4 | 1.51 |
| Livestock vaccination and treatment | 0.27 | 22.6 | 1.08 |
| Purchase of hay | 0.13 | 21.0 | 0.71 |
| Water tankering | 0.13 | 18.6 | 0.14 |
| Survey of migration routes | 0.00 | 17.0 | -0.24 |
| Purchase of commercial feeds and supplements | 0.07 | 15.4 | -0.61 |
| Destocking | 0.00 | 7.0 | -2.59 |

H = 9.97 (adjusted for ties) with 6 df, Probability > 9.97 = 0.1259

4.3.2.2 Adaptation strategies being applied during rain or flood related disasters by pastoralists in Kajiado

The adaptation strategies identified by the pastoralists to be commonly applied during rains or floods related disasters included stocking of hay, deworming, fencing and paddocking, timed grazing, growing more napier grass, hay bailing, livestock vaccination and treatment, mineral supplementation, pasture conservation, preservation of maize stock, restocking, water harvesting and zoning of grazing areas. The listed strategies were ranked by the pastoralists through simple ranking and pairwise ranking and probing giving ranking scores. The results are shown on Annexes 6 and 7. The average scores obtained during the rankings were then analyzed using Kruskal-Wallis h test to determine if the obtained scores showed any significant difference from the zero score and the results are shown on Table 9.

Table 9: Adaptation strategies being applied during rain or flood related disasters by pastoralists in Kajiado

| Adaptation strategy applied by pastoralists | Median | Average rank | z-score |
|---|--------|--------------|---------|
| Livestock vaccination and treatment | 0.17 | 64.2 | 2.78 |
| Fencing and paddocking | 0.20 | 51.4 | 1.42 |
| Water harvesting | 0.10 | 51.4 | 1.42 |
| Restocking | 0.00 | 42.5 | 0.48 |
| Timed grazing | 0.00 | 37.4 | -0.09 |
| Buying and stocking of hay | 0.00 | 35.9 | -0.22 |
| Growing more Napier grass | 0.00 | 35.1 | -0.31 |
| Mineral supplementation | 0.00 | 35.1 | -0.31 |
| Zoning of grazing areas | 0.00 | 34.4 | -0.38 |
| Deworming | 0.00 | 33.9 | -0.44 |
| Hay bailing | 0.00 | 31.8 | -0.66 |
| Preservation of maize stock | 0.00 | 26.5 | -1.22 |
| Pasture conservation | 0.00 | 26.5 | -1.79 |

H = 23.85 (adjusted for ties) with 12 df, Probability > 23.85 = 0.0213

4.3.3 DISCUSSIONS

In addressing climate variability effects during drought period, pastoralists in Kajiado employ several response strategies. The simple ranking indicated that migration was ranked highly in East and South, while survey of migration area was ranked highly in Kajiado Central and West. Livestock vaccination and treatment was ranked second highest in Kajiado East, South and West. Water tankering was ranked third in Kajiado East and South. Purchase of hay was ranked first in Kajiado North where livestock keeping is sedentary. Destocking was the least preferred in Kajiado East and South but was preferred in the sedentary livestock sub county of Kajiado North. With pairwise ranking and probing, migration had the highest score for Kajiado East, South and Central while livestock vaccination and treatment had the second highest score for Kajiado South, East and West. Survey of grazing area had the highest score for Kajiado Central and West. Destocking was the least preferred as indicated by the zero score.

Analysis through the Kruskal-Wallis h test showed that all the strategies were equally being practiced during drought related disasters with $p=0.1259$. However, migration ($z=1.51$), livestock treatment and vaccination ($z=1.08$), purchase of hay ($z=0.71$) and water tankering ($z =0.14$) appear to be practiced more during drought. The least practiced strategies were destocking ($z= -2.59$), purchase of commercial feeds and supplements ($z= -0.61$) and survey of grazing area ($z= -0.24$).

The simple ranking of strategies being applied during rain or flood-related disasters showed that fencing and paddocking was highly ranked in Kajiado East and West, livestock vaccination and treatment in Kajiado Central and West and buying and stocking hay in the sedentary system of Kajiado North. Zoning of grazing area was ranked second highest in Kajiado South, mineral supplementation in Kajiado Central, grazing timing in Kajiado East and restocking in Kajiado West. Restocking was least preferred in Kajiado South, hay bailing in Kajiado South and pasture conservation in Kajiado West. With pairwise ranking and probing, fencing and paddocking had highest score for Kajiado East and South, zoning of grazing area for Kajiado South and livestock vaccination and treatment for Kajiado South, Central and West. Hay bailing had the lowest score for Kajiado South and North.

The Kruskal-Wallis h test indicated that the strategies applied during rain or flood related disaster were also equally being practiced across the County but livestock vaccination and treatment ($z=2.78$) was more frequently being practiced during rain or flood-related disasters by the pastoralists. Other commonly practiced interventions during rain or flood-related disasters included fencing and paddocking ($z=1.42$), water harvesting ($z=1.42$) and restocking ($z=0.48$) with the least practiced interventions including pasture conservation ($z= -1.79$), preservation of maize stock ($z= -1.22$), deworming ($z= -0.44$) and zoning of grazing area ($z= -0.38$). For the strategies that were highly ranked (both during drought and during rains) such as migration and livestock vaccination and treatment, they had the middle value among the other strategies, they were more common compared to the other strategies and they were highly above the mean of the other strategies.

With prolonged and frequent drought, the Kajiado pastoralists' major adaptation strategy was found to be livestock migration where the animals were being moved in search of pasture and water. Migration was found to be occurring either within the County, outside the County to other surrounding counties or to the Republic of Tanzania. Before migration, it was mandatory that the pastoralists carry out a survey of the routes for migration where the livestock were to be migrated to. According to the pastoralists, survey of migration routes is being treated as an adaptation strategy that had to be undertaken before the animals were moved to new areas of grazing since with the new environment, the animals were being exposed to new disease which needed to be established before movement. So it was important to establish the disease and pasture situation before migration hence the survey of migration routes.

Livestock movement during migration was associated with spread and increment in the occurrence of diseases of animals. Likewise, with onset of rainy season was also associated with increment on livestock disease incidences calling for protection of animals against the diseases. This created the need for livestock vaccination and treatment before or after movements and during the rainy seasons to prevent any losses associated with diseases. Reportedly there was higher demand for vaccines and drugs during the rainy season compared to dry seasons. Pasture depletion and drying up water sources associated with recurrent and prolonged drought necessitated purchase of hay and other commercial feeds to supplement the inadequate pasture and ferrying of water (water tankering) from other sources to where the animals had migrated to. However, the rainy seasons were occasionally associated with increased pasture and uncontrolled flowing rain water. Therefore, the pastoralists were responding by conserving pasture either as standing hay through fencing and paddocking, zoning of grazing, timed grazing, or through bailing to secure the pasture for the next anticipated drought period but the capacity to conserve pasture in the form of hay by the pastoralists was reportedly limited due to availability of resources. Some pastoralists were also responding by harvesting water through roof catchments or constructed dams and water pans to secure water for livestock and human beings for the next anticipated drought but this was limited as the resources minimal.

The strategies were being applied to reduce drought or flooding effects on pastoralism within the County and at the same time aiming at reducing climate-related effects that were already being felt by the pastoralists on livestock production. According to IPCC (2007), the changes in climate would result in changes that might include increased heat waves, intense rainfall, extensive and recurrent drought, rise in sea levels and intensive storms and that livestock production and human settlements are expected to be negatively impacted with expected major losses in life, social disruption and economic hardship. Speranza (2010), reported that frequent droughts in ASALs are associated with increased incidence of livestock diseases, loss of livestock body condition and deaths. According to Boko *et al.* 2007, the combined effects of climate change and variability and reduced vegetation cover/deforestation are leading to biodiversity loss thus putting biodiversity at risk. Impacts of climatic changes were expected to be more felt not only within Kajiado but also in other ASALs with negative effects on livestock and the pastoral livelihoods. Mechanisms to address the effects of the changing climate are required to prevent further human and livestock losses in the County. According

to Kiriimi *et al* (2013), the pastoralists now need more than the indigenous knowledge to adapt to the changes in climate.

CHAPTER FIVE

SYNTHESIS AND DISCUSSION

The study has shown that pastoralists in Kajiado County live in an environment that exhibits noticeable variations in temperature and rainfall. The variability was demonstrated by the increase in coefficients of variation in rainfall and temperature. The variations in temperature and rainfall have been observed to have become regularly common in Kajiado with droughts increasingly becoming frequent and prolonged. The variability has significant effects on pastoralism that supports livelihood for most of the populace within Kajiado. The bi-modal rainfall seasonality in the County has been observed to have greatly changed as the rainfall has become unreliable and unpredictable seriously affecting the pastoral production system. These climatic changes are leading to diminishing sources of water, biodiversity loss, inadequacy in pasture, emergence of or increment on incidence of livestock diseases and massive livestock deaths with resultant poor livestock productivity in the County.

Therefore, these seasonal variations have had effects on pastoralism with the vulnerability of pastoralists increasing under the changing climate. There was confirmation to this vulnerability during the years 2006, 2008 and 2009 droughts where there were reported livestock deaths in excess of 70% in most parts of the County. Massive livestock deaths and low livestock productivity are impacting negatively on pastoralists since the pastoralists rely on pastoralism as their main source livelihoods in the County. The community's observation was that livestock disease incidence and prevalence have increased with these diseases adversely affecting major livestock species (cattle, sheep and goats) that support pastoralism as a production system in the County. Livestock diseases are therefore posing a serious challenge to the pastoral production system in Kajiado with expected serious outcome on the future of pastoralism in the County. The livestock diseases are threatening livestock production system since they cause livestock deaths and reduction in livestock productivity. Pastoralists' observation was that with proper livestock disease interventions especially vaccinations, incidence of some of the diseases could be reduced to minimal levels.

Although the pastoralists are faced with several production challenges associated with climate variability, pastoralists themselves have also been responding to the changes in climate through indigenously developed strategies to counter effects of climatic changes. There were several suggested intervention measures that could address the production challenges and thus

reduce further vulnerabilities arising from climate variability on pastoralists in Kajiado. In an effort to address the production challenges, more effort should be put on the development of prioritized strong cross-cutting county adaptation strategies with the involvement of sectors such as agriculture, livestock, water, health and NDMA through development of well-coordinated action plans aimed at supporting the pastoral adaptation strategies in the County. The climate change adaptations or interventions should take a form of specific actions or projects aimed at addressing effects of climate variability in the County. Although it was also noted that some of these actions or projects might require significant resources from the County Government, pastoralists themselves or other investors interested in supporting the sustainability of pastoralism in the County.

In Kajiado, increment on pastoralists' vulnerability to climate variability and change is being aggravated by over relying on livestock production for their livelihoods. With the changing climate, pastoralists and the County government should implement the opportunities, such as pasture production and conservation, water harvesting and management and livestock insurance, identified during the study for sustainability of their pastoral livelihood. Alternatively, the pastoralists should diversify their livelihood, as the future of livestock production system and by extension pastoralism as a source of livelihood support looks uncertain under the changing climatic conditions.

To address the increase on incidence of livestock diseases and pests as a challenge, the County government should put in place effective animal disease control services that would ensure that diseases and pests are properly prevented and controlled during drought or rainy seasons to reduce the impacts of the diseases on the pastoral production system. The effective disease control services would also address livestock deaths being caused by livestock diseases. On the unavailable and expensive vaccines and drugs, the County in collaboration with other partners should avail subsidized veterinary drugs and vaccines for prevention and control of livestock diseases at the time when they are required. With inadequate technical staff, there is urgent need for the County to recruit and deploy adequate technical staff to assist in effective administration of the vaccines and drugs and extension services on the control of livestock diseases in the County.

The massive livestock deaths that were being caused by starvation arising from scarcity of pasture and other livestock feeds and long distance trekking in such of pasture and water, could be addressed through effective livestock extension services on pasture production and

conservation. This could increase the capacity of the pastoralists to produce and conserve adequate pasture especially during the rainy seasons ensuring availability of pasture and feed for livestock, thus minimizing migration during drought. This should also be coupled with construction of hay storage facilities and provision of pasture seeds, hay planting and harvesting equipment by government to facilitate production and conservation. This would also address the challenges of low pasture productivity, expensive, low quality and unavailable hay and commercial animal feeds being experienced by the pastoralists during drought.

Where losses might be inevitable, the pastoralists should also consider insuring their animals through livestock insurance scheme for compensation for livestock lost, especially during prolonged droughts. When addressing the issue of pasture production, the government should address issue of land subdivision which has caused reduction in the group ranches that were originally meant to be grazing land for the livestock. There is need for the development of land use programme that would ensure that the ranches are protected and grazing land maintained for sustainability of livestock production hence pastoralism in the County. Water as a challenge could be addressed through a concerted effort the government, pastoralists and other partners through construction of more boreholes, water pans and dams and water harvesting through roof catchments and channelling run-off waters to the constructed dams and water pans for use during drought. Feedlots as an opportunity would also ensure that the perennial losses encountered by the pastoralists as a result of massive livestock deaths occasioned by climate variability are minimized with consequent financial gain from the sale of the livestock.

The impacts of climate variability coupled with the reduction in the grazing areas are piling pressure on pastoralism as a production system in the County further diminishing the pastoralists' chances of surviving with large herds of cattle and other animals. Therefore, pastoralists should culturally accept destocking and start keeping fewer herds that could be supported by the available land and pasture. Alternatively, they should start cross-breeding and acquisition of small-bodied animals such sheep and goats that would be ecologically compatible with climatic changes or do destocking before climate-related disasters and restock during the rainy seasons. Destocking could be undertaken through reduction of overall number of livestock in the herd through sale or slaughter and putting the generated money into other investments that might not be climate-dependent such as housing, savings, etc. or

restock the livestock when pasture is available. The production challenges faced by the pastoralists in Kajiado might require them to think of other livelihood alternatives. The alternative livelihoods the pastoralists could consider crop farming through irrigation, bee keeping and fish farming. Alternatively, pastoralists could also opt out of pastoralism and invest in housing, savings and education and keep fewer but high producing dairy animals instead of large number of herds.

Extra effort should be put by the pastoralists and the County government to ensure that the vegetative cover in areas where the landscape systems have been degraded are conserved and restored. This would ensure maximum pasture growth and water availability. The County government should borrow from the National government especially on policy framework on climate change adaptation to provide guidelines and regulations that govern climate change adaptation strategies at the county level. The strategies should consider the historical knowledge of the pastoralists coupled with their experience in dealing with frequently changing environment given the pastoralists' understanding and knowledge of environmental changes when it comes to the development of grazing practices and adaptation strategies. This has been in consistency with pastoralists' environment, social and cultural context. The current subdivision and sale of land for human settlement and industrial use is affecting the pastoralists' adaptive capacity, calling for the development of more appropriate and relevant adaptation strategies that could enable the pastoralists to address these emerging challenges. Pastoralists are now faced with many challenges among them sustaining pastoralism without interfering with environment, increasing human population, poor governance, climatic changes and change of land use as a result of other competing activities such as industrialization and human settlement.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The research study has conclusively shown that there is evidence of climate variability in Kajiado as shown by increase in the coefficient of variation for rainfall amounts and temperature. The climate variability is significantly impacting on pastoralists' livelihood sources. The pastoralists are in turn are implementing several adaptation measures to mitigate the impacts of climate variability. Challenges with significant impact on pastoralism in the County include increased occurrence of diseases of livestock, massively occurring livestock deaths, water unavailability and unavailable hay and other animal feeds. The study has shown that migration, livestock vaccination and treatment, purchase of hay and water tankering are more commonly practiced during drought seasons while livestock vaccination and treatment, fencing and paddocking, water harvesting and restocking were commonly practiced during rainy or flood-related.

Challenges/impacts could be addressed through the interventions such as effective animal disease control services, provision of subsidized veterinary vaccines and drugs, recruitment and deployment of adequate technical staff and improved livestock extension services. The opportunities that could be exploited to reduce vulnerability to climate change and variability include pasture production and conservation especially during the rainy seasons, water conservation and management and construction of hay storage facilities.

The study has established that the emerging challenges for the pastoralists include climate change/variability, increase in human population and subdivision and sale of land for human settlement and industrial development. The change of land tenure is significantly reducing the practice of pastoralism. Among the preferred adaptation strategies, priority could be given to migration, livestock vaccination and treatment, purchase of hay, pasture conservation, water harvesting and destocking. For opportunities to support sustainability of pastoralism, priority should be given to investment on pasture production and conservation, acceptance of destocking by the pastoralists, water conservation and management and introduction of livestock insurance scheme.

To safeguard pastoralism, there is need for formulation of policies and laws at National and County levels. For Department of Livestock at the County level, there should be a policy that

could guide on drought management strategies, predetermined intervention criteria and the relevant emergency action plans targeting livestock while for the State Department of Livestock, there should be policy framework on climate change adaptation to provide guidelines and regulations to govern climate change adaptation strategies at the level of the County. The laws and policies at County level should aim at strengthening the livestock sector through targeted interventions such as pasture production and conservation, animal health services (disease control and surveillance, veterinary legislation, inadequate technical staff, etc.), livestock marketing and extension services, water conservation and land use plans and strategies and livelihood diversification targeting viable alternative livelihoods.

At the National level, there should be a policy framework that recognizes pastoralism as an economic and productive land use for the purposes of economic planning by the National Government in order to support and give services to pastoral production areas with the aim of addressing the challenges of changing climate. The need for a policy focus on pastoralism is because pastoralists are considered among the marginalized community and their access to socio-economic services and infrastructure is limited. Secondly, to successfully achieve inclusive national development targets, attention should also be given to ASALs.

With right policies, pastoral production system in the County could be more productive and profitable since the system still remains the only suitable user of pastoral lands within the ASALs compared to crop agriculture but at the same time create alternative livelihood opportunities. Therefore, it is also important to build pastoralists' capacity to adapt to climate change/variability by enabling and strengthening their indigenous adaptive capacity and encouraging their autonomous adaptation. The policies should be developed with the aim of strengthening resilience of the pastoralist within Kajiado towards impacts of the changing climate. The strategies or policies should target management of grazing land through clear land tenure system, livestock productivity and marketing and diversification of pastoral livelihoods.

There is need for the County to give consideration to the land use plans and strategies with the current climate scenarios given that its major resources are livestock and wildlife as the County currently lacks land use and land zonation strategy that is comprehensive and enforceable. This would stop the haphazard growth and spread of settlements and industries at the expense of pastoralism as the main source of livelihoods. Short-term and long-term intervention plans for livestock need to be urgently developed and if possible climate change

should be mainstreamed within the CIDPs to provide a legislative roadmap that should integrate climate change adaptation and mitigation in policy, planning, budgeting and implementation at the County level. The County government should promote alternative livelihoods such as bee keeping, fish farming, agriculture, etc. aimed complementing livestock production system and improving the general lives of the pastoralists. The need to prioritize and put in place investments that could build pastoralists' resilience to climate change/variability is overdue. These investments should aim at commercialization of fodder production and conservation, establishment of livestock marketing infrastructure and increased water management and conservation.

The findings are useful for policy making with regard to designing appropriate measures that would support resilience of vulnerable pastoralists in Kajiado and other pastoral communities and help in addressing the adverse impacts of climatic changes.

6.2 RECOMMENDATIONS

The study has recommended that laws and policies be formulated and implemented to assist in the management of pastoral production system with the advent of climate change and variability to support resilience of pastoral community in Kajiado. The policies and laws should aim at strengthening the livestock sector through targeted interventions such as pasture production and conservation, animal health services (disease control and surveillance, veterinary legislation, inadequate technical staff, etc.), livestock marketing and extension services, water conservation and management, land use plans and strategies and alternative livelihoods that would complement livestock as a production system.

The study also recommends the development of Community Based Early Warning System (CBEWS) that should be able to give indicators for drought, animal diseases and conflict areas among others at the County level.

The study further recommends increased awareness campaigns among the pastoralists on the changing climate to make them prepared to adjust and adapt to the new challenges that are associated with the changing climatic conditions.

The changing climate is posing new challenges to traditional pastoral production system in the County, the study therefore recommends further research on how the indigenous knowledge of the pastoral community could be harnessed to assist in addressing the climate change and variability for sustainability of pastoralism and for economic viability of the pastoralism that

could warrant future investment on pastoralism as production system in the County and other ASALs under the changing climate.

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ANNEXES

ANNEX 1: LETTER OF INTRODUCTION

**ACHOLA JACKTONE YALA,
P. O. BOX 8912-00200
NAIROBI.
DATE.....**

To
.....

RE: DATA COLLECTION

I am a postgraduate student pursuing a PhD Degree in Climate Change and Adaptation at the Institute of Climate and Adaptation, University of Nairobi. I am carrying out a research on the Sustainability of Pastoralism under a Changing Climate in Kajiado County in partial fulfilment of requirement for the PhD Degree in Climate Change and Adaptation.

I will therefore appreciate your cooperation and assistance in completing the questionnaire and any other questions you may be asked through interviews. The information you provide will be strictly for the purpose of this study and will be used purely for academic purposes.

The confidentiality regarding the information and your identity will be strongly guarded. Please answer all questions as honestly as possible and do not hesitate to ask for clarification where you don't understand.

I appreciate your time and responses in advance.

Thank you.

Yours faithfully

Achola Jacktone Yala

ANNEX 2: CHECK LIST FOR INTERVIEWS FOR QUALITATIVE APPROACHES (FGD, KII AND EOI)

Climate trends and livestock disease occurrence and interventions in view of climate change and variability in Kajiado County

1. Are you aware of Climate Change?
2. What are the parameters that show that climate has changed?
3. How have these parameters changed over a period of time in the County?
4. What are the impacts of these climatic changes on livestock in the County?
5. How is the occurrence of livestock diseases in relation to changing climate in the County?
6. What livestock disease interventions are in place to control livestock diseases?
7. How have interventions affected occurrence of livestock diseases?

To determine current adaptation strategies applied by Maasai pastoralists to mitigate against climate variability and change effects in Kajiado
Adaption measures during drought

1. How do you always respond to occurrence of drought?

List the responses

2. Which of these measures are frequently practiced or applied?

List the responses

3. How do you rank these measures in terms of priority?

Simple Ranking

| Sub County | A | B | C | D | E |
|--------------------|---|---|---|---|---|
| Adaptation Measure | | | | | |
| A | | | | | |
| B | | | | | |

4. How do you further rank these measures in relation to one another?

Pairwise Ranking and Probing (Probing and asking questions “why”)

| Sub County | A | B | C | D | E |
|--------------------|---|---|---|---|---|
| Adaptation Measure | | | | | |
| A | | | | | |
| B | | | | | |

Adaption measures during floods/Rains

1. Which adaption measures are practiced during floods/rains?

List the measures

2. Which of these measures are frequently practiced or applied? List the responses

3. How do you rank these measures in terms of priority?

Simple Ranking

| Sub County | A | B | C | D | E |
|--------------------|---|---|---|---|---|
| Adaptation Measure | | | | | |
| A | | | | | |
| B | | | | | |

4. How do you further rank these measures in relation to one another?

Pairwise Ranking and Probing (Probing and asking questions “why”)

| Sub County | A | B | C | D | E |
|--------------------|---|---|---|---|---|
| Adaptation Measure | | | | | |
| A | | | | | |
| B | | | | | |

To identify challenges and opportunities with implementation of the current adaptation strategies by the Maasai pastoralist in Kajiado County

1. Which are the challenges when implementing adaptation strategies to climate change and variability in the County?

List adaptation strategies and challenges

2. What is do you propose as an intervention for these challenges?

List the adaptation, challenge and intervention

3. Livestock diseases as a challenge: Which livestock diseases are prevalent in goats, sheep and Cattle the changing climate in the County?

List diseases

4. How do rank the diseases in terms of prevalence?

Simple ranking

| Sub County | A | B | C | D | E |
|------------|---|---|---|---|---|
| Disease | | | | | |
| A | | | | | |
| B | | | | | |

5. How do you further rank these diseases?

Pairwise Ranking and Probing (Probing and asking questions “why”)

| Sub County | A | B | C | D | E |
|------------|---|---|---|---|---|
| Disease | | | | | |
| A | | | | | |
| B | | | | | |

6. What opportunities are available when implementing adaptation strategies to climate change and variability?

b) Can you suggest the implementation framework for the identified opportunity?

List the opportunity and implementation framework

| Sub county | Opportunities identified | Proposed implementation framework |
|------------|--------------------------|-----------------------------------|
| | | |

ANNEX 3: LOCATIONS FOR FOCUS GROUP DISCUSSIONS

| Sub County | Location | Men | Women | Latitude (Y) | Longitude (X) |
|-----------------|-------------------|-----|-------|--------------|---------------|
| Kajiado West | Ol Tepesi | 9 | 5 | -1.533578 | 36.596717 |
| Kajiado West | KMQ | 8 | 2 | -1.924886 | 36.633998 |
| Kajiado South | Imbirikani | 8 | 4 | -2.53975 | 37.527342 |
| Kajiado South | Olgulului | 7 | 4 | -2.592735 | 36.980127 |
| Kajiado North | Nkoroi (Lemelepo) | 6 | 0 | -1.410068 | 36.717277 |
| Kajiado North | Erankau | 8 | 3 | -1.403525 | 36.804907 |
| Kajiado East | Olturoto | 7 | 0 | -1.586893 | 36.911211 |
| Kajiado East | Ilmunkush | 12 | 4 | -1.866916 | 37.073207 |
| Kajiado Central | Ngiito | 6 | 6 | -2.352139 | 36.677723 |
| Kajiado Central | Namanga | 10 | 5 | -2.526111 | 36.82451 |

ANNEX 4: SIMPLE RANKING FOR ADAPTATION STRATEGIES APPLIED DURING DROUGHT RELATED DISASTERS

| Sub County | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|--|----------------|---------------|-----------------|--------------|---------------|
| Adaptation strategy | Ranking | | | | |
| Destocking | 6 | 6 | - | - | 3 |
| Livestock vaccination and treatment | 2 | 2 | 3 | 2 | - |
| Migration | 1 | 1 | 2 | 3 | - |
| Purchase of commercial feeds and supplements | 5 | 5 | 6 | 6 | 2 |
| Purchase of hay | 4 | 4 | 5 | 5 | 1 |
| Survey of migration routes | - | - | 1 | 1 | - |
| Water tankering | 3 | 3 | 4 | 4 | - |

ANNEX 5: PAIRWISE RANKING AND PROBING OF ADAPTATION STRATEGIES APPLIED DURING DROUGHT RELATED DISASTERS

| Sub County | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|--|--------------|---------------|-----------------|--------------|---------------|
| Adaptation strategy | Count | | | | |
| Destocking | 0 | 0 | - | 0 | 0 |
| Livestock vaccination and treatment | 4 | 4 | 3 | 4 | - |
| Migration | 5 | 5 | 4 | 3 | - |
| Purchase of commercial feeds and supplements | 1 | 1 | 0 | 0 | 1 |
| Purchase of hay | 2 | 2 | 1 | 1 | 2 |
| Survey of migration routes | - | - | 5 | 5 | - |
| Water tankering | 3 | 3 | 2 | 2 | - |

**ANNEX 6: SIMPLE RANKING OF ADAPTATION STRATEGIES APPLIED
DURING RAIN OR FLOOD RELATED DISASTER BY PASTORALISTS**

| Sub County | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|-------------------------------------|---------------------|----------------------|------------------------|---------------------|----------------------|
| Adaptation | Ranking | | | | |
| Buying and stocking of hay | - | - | - | - | 1 |
| Deworming | - | - | - | - | 3 |
| Fencing and paddocking | 1 | 1 | 5 | 3 | - |
| Timed grazing | 2 | 4 | - | - | - |
| Growing more Napier grass | - | - | - | - | 2 |
| Hay bailing | - | 6 | - | - | - |
| Livestock vaccination and treatment | 4 | 3 | 1 | 1 | 4 |
| Mineral supplementation | - | - | 2 | - | - |
| Pasture conservation | 5 | - | - | 5 | - |
| Preservation of maize stock | - | - | - | - | 5 |
| Restocking | - | 7 | 3 | 2 | - |
| Water harvesting | 3 | 5 | 4 | 4 | - |
| Zoning of grazing areas | - | 2 | - | - | - |

**ANNEX 7: PAIRWISE RANKING AND PROBING OF ADAPTATION
STRATEGIES APPLIED DURING RAIN OR FLOOD RELATED DISASTER
BY PASTORALISTS**

| Sub County | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|-------------------------------------|---------------------|----------------------|------------------------|---------------------|----------------------|
| Adaptation strategy | Ranking | | | | |
| Buying and stocking of hay | - | - | - | - | 4 |
| Deworming | - | - | - | - | 2 |
| Fencing and paddocking | 4 | 6 | 0 | 2 | - |
| Timed grazing | 3 | 3 | - | - | - |
| Growing more Napier grass | - | - | - | - | 3 |
| Hay bailing | - | 1 | - | - | - |
| Livestock vaccination and treatment | 1 | 4 | 4 | 4 | 1 |
| Mineral supplementation | - | - | 3 | - | - |
| Pasture conservation | 0 | - | - | 0 | - |
| Preservation of maize stock | - | - | - | - | 0 |
| Restocking | - | 0 | 2 | 3 | - |
| Water harvesting | 2 | 2 | 1 | 1 | - |
| Zoning of grazing areas | - | 5 | - | - | - |

**ANNEX 8: SIMPLE RANKING: PREVALENT LIVESTOCK DISEASES OF
CATTLE THAT AFFECT PRODUCTION UNDER A PASTORALIST
SYSTEM IN KAJIADO**

| | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|-----------------------------------|-------------------------|--------------------------|----------------------------|-------------------------|--------------------------|
| Disease | Ranking | | | | |
| Anaplasmosis | 6 | 6 | 6 | 6 | 2 |
| Babesiosis | 7 | 7 | - | - | 6 |
| Black Quarter/Anthrax | 2 | 3 | 2 | 2 | 3 |
| Contagious Bovine PleuroPneumonia | - | 4 | - | 4 | - |
| East Coast Fever | 4 | 5 | 4 | 3 | 1 |
| Foot and Mouth Disease | 1 | 1 | 1 | 1 | 7 |
| Heartwater | 5 | - | - | - | - |
| Helminthiosis | 8 | 8 | 5 | 5 | 8 |
| Lumpy Skin Disease | 3 | 2 | 3 | - | - |
| Mastitis | - | - | - | - | 4 |
| Pneumonia | - | - | - | - | 5 |
| Trypanosomiasis | - | - | - | 7 | - |

**ANNEX 9: SIMPLE RANKING: PREVALENT LIVESTOCK DISEASES OF
SHEEP THAT AFFECT PRODUCTION UNDER A PASTORALIST SYSTEM
IN KAJIADO**

| | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|----------------------------|-------------------------|--------------------------|----------------------------|-------------------------|--------------------------|
| Disease | Ranking | | | | |
| Blue Tongue | 3 | 3 | 7 | 4 | 1 |
| Coenurosis | 2 | 4 | 3 | 1 | - |
| Enterotoxaemia | 4 | 2 | 2 | - | - |
| Helminthiosis | 5 | 6 | 6 | 5 | 4 |
| Pneumonia | - | - | 8 | - | 2 |
| Pestes des Petit Ruminants | 1 | 1 | 1 | 2 | - |
| Sheep and Goat Pox | - | - | 5 | 3 | - |
| Rift Valley Fever | - | 5 | 4 | - | 3 |

ANNEX 10: SIMPLE RANKING: PREVALENT LIVESTOCK DISEASES OF GOATS THAT AFFECT PRODUCTION UNDER A PASTORALIST SYSTEM IN KAJIADO

| | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|------------------------------------|---------------------|----------------------|------------------------|---------------------|----------------------|
| Disease | Ranking | | | | |
| Blue Tongue | - | - | - | - | - |
| Contagious Caprine PleuroPneumonia | 1 | 1 | 1 | 2 | - |
| Coenurosis | 2 | 2 | 2 | 1 | - |
| Heartwater | 3 | 3 | 3 | 5 | - |
| Helminthiosis | 5 | - | 7 | 6 | 2 |
| Pneumonia | - | 6 | 6 | - | 1 |
| Pestes des Petit Ruminants | 4 | 5 | 5 | 4 | - |
| Rift Valley Fever | - | 4 | 4 | 3 | - |

ANNEX 11: PAIRWISE RANKING AND PROBING: PREVALENT LIVESTOCK DISEASES OF CATTLE THAT AFFECT PRODUCTION UNDER A PASTORALIST SYSTEM IN KAJIADO

| | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|-----------------------------------|---------------------|----------------------|------------------------|---------------------|----------------------|
| Disease | Count | | | | |
| Anaplasmosis | 2 | 2 | 0 | 1 | 6 |
| Babesiosis | 1 | 1 | - | - | 2 |
| Black Quarter/Anthrax | 6 | 5 | 4 | 5 | 5 |
| Contagious Bovine PleuroPneumonia | - | 4 | - | 3 | - |
| East Coast Fever | 4 | 5 | 2 | 4 | 7 |
| Foot and Mouth Disease | 7 | 7 | 5 | 6 | 1 |
| Heartwater | 3 | - | - | - | - |
| Helminthiosis | 0 | 0 | 1 | 2 | 0 |
| Lumpy Skin Disease | 5 | 6 | 3 | - | - |
| Mastitis | - | - | - | - | 4 |
| Pneumonia | - | - | - | - | 3 |
| Trypanosomiasis | - | - | - | 0 | - |

**ANNEX 12: PAIRWISE RANKING AND PROBING: PREVALENT
LIVESTOCK DISEASES OF SHEEP THAT AFFECT PRODUCTION UNDER
A PASTORALIST SYSTEM IN KAJIADO**

| | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|----------------------------|-------------------------|--------------------------|----------------------------|-------------------------|--------------------------|
| Disease | Count | | | | |
| Blue Tongue | 2 | 3 | 1 | 1 | 3 |
| Coenurosis | 3 | 2 | 5 | 4 | - |
| Enterotoxaemia | 1 | 4 | 6 | - | - |
| Helminthiosis | 0 | 0 | 2 | 0 | 0 |
| Pneumonia | - | - | 0 | - | 2 |
| Pestes des Petit Ruminants | 4 | 5 | 7 | 3 | - |
| Sheep and Goat Pox | - | 0 | 3 | 2 | - |
| Rift Valley Fever | - | 1 | 4 | - | 1 |

**ANNEX 13: PAIRWISE RANKING AND PROBING: PREVALENT
LIVESTOCK DISEASES OF GOATS THAT AFFECT PRODUCTION UNDER
A PASTORALIST SYSTEM IN KAJIADO**

| | Kajiado East | Kajiado South | Kajiado Central | Kajiado West | Kajiado North |
|------------------------------------|-------------------------|--------------------------|----------------------------|-------------------------|--------------------------|
| Disease | Count | | | | |
| Blue Tongue | - | - | - | - | - |
| Contagious Caprine Pleuropneumonia | 4 | 5 | 6 | 4 | - |
| Coenurosis | 3 | 4 | 5 | 5 | - |
| Heartwater | 2 | 3 | 4 | 1 | - |
| Helminthiosis | 0 | 0 | 0 | 0 | 0 |
| Pneumonia | - | - | 1 | - | 1 |
| Pestes des Petit Ruminants | 1 | 1 | 2 | 2 | - |
| Rift Valley Fever | - | 2 | 3 | 3 | - |