



**UNIVERSITY OF NAIROBI**

**DEPARTMENT OF EARTH AND CLIMATE SCIENCES**

**APPRAISAL OF THE CLIMATE CHANGE RESILIENCE OF A PASTORAL SOCIAL-  
ECOLOGICAL SYSTEM: A CASE STUDY OF THE MAASAI COMMUNITY IN  
KAJIADO COUNTY, KENYA.**

**By**

**KAOGA JAMES OTIENO**

**(185/93803/2014)**

**A thesis submitted in partial fulfilment of the requirements for the degree of Doctor  
of Philosophy in Climate Change and Adaptation in the department of Earth and  
Climate Sciences of the University of Nairobi**

**2021**

## PLAGIARISM STATEMENT

I declare that this thesis is my original work and has not been submitted elsewhere for research where other people's work have been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements. ¶

Signature:  .....Date 2<sup>nd</sup> August, 2021 ¶


Kaoga James Otieno ¶  
(185/93803/2014) ¶

This thesis has been submitted to the Department of Earth and Climate Sciences in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Climate Change and Adaptation of the University of Nairobi with our approval as supervisors. ¶

### SUPERVISORS ¶

Prof. Daniel Olago, D.Phil. ¶

University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya. ¶

Signature:  .....Date..... 02/08/2021 ..... ¶


Prof. George Ouma, PhD. ¶

University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya. ¶

Signature:  .....Date: ..... 2/08/2021 ..... ¶

Prof. Gilbert Ouma, PhD. ¶

University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya. ¶

Signature:  .....Date 2/8/2021 ..... ¶

Dr. Joshua Onono, PhD. → ¶

University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya. ¶

Signature:  .....Date..... 2/08/2021 ..... ¶

## **DEDICATION**

I would desire to dedicate this thesis to my beloved wife Concepta, my children; Konjra, Mich and Hawi for their support.

## **ACKNOWLEDGEMENT**

I am grateful to Prof. Daniel Olago, Prof. George Ouma, Prof. Gilbert Ouma and Dr. Joshua Onono for their advice and guidance throughout the study. I would also wish to express my appreciation to the National Drought Management Authority (NDMA) Kajiado office, Regional Centre for Mapping of Resource for Development (RCMRD), IGAD Climate Prediction and Application Centre (ICPAC) and Kenya Meteorological Department for their logistic and technical support. Lastly, I express sincere gratitude to the National Council of Science and Technology Innovation (NACOSTI) for their financial support throughout this project.

## ABSTRACT

Kajiado County is largely Arid and Semi-Arid Lands (ASALs). The Maasai pastoralists, who are the predominant community inhabiting the County, have been faced with persistent droughts leading up to 30 per cent loss of their livestock annually and this is attributed to climate-related disasters. The situation has been aggravated by the land use transformation since what was formerly communal land has been converted to private holding which is not in harmony with the traditional seasonal movement of livestock. This has contributed to the rampant food insecurity in the county. To address this gap, the research investigated the impacts of climate change and land-use changes on the pastoral Social-Ecological System in Kajiado County. The specific objectives of the study were: to determine historical climate trend and its impacts on pastoral livelihoods, to evaluate the pastoral Socio-Ecological System and its influence on pastoralists' livelihood and lastly, to determine adaptation strategies to enhance the resilience of the pastoral Socio-Ecological System to climate change and land-use transformation. The study used a mixed-method design which involved qualitative and quantitative data. Primary datasets consisted of 195 questionnaires for Household survey, 18 Key Informant Interviews and 8 Focus Group Discussions. These tools were complemented with secondary datasets, which consisted of Climate Hazards Group Infra-Red Precipitation with Stations (CHIRPS) precipitation data from 1983 to 2014, monthly temperature for the period 1970 to 2014 from Kenya Meteorological Department and Landsat 8, 5 and 4. The 1987, 2000 and 2015 epochs were sourced from [www.glovis.usgs.org](http://www.glovis.usgs.org). The datasets at various points were analysed using time series, t-test, frequencies, scores and themes. The study revealed declining annual rainfall trend and unreliability of seasonal precipitation patterns which were compounded with rising temperatures ( $T_{max}$  and  $T_{min}$ ). Additionally, changes in land use patterns were observed within the landscape with the forested land, grassland, riverine, shrubland, waterbody, bare area, built-up area, wetland and cropland having undergone changes in their sizes. Furthermore, the invasive species had spread into significant areas of the grassland areas thus suppressing indigenous and palatable pastures. Consequently, the Maasai pastoralists have been left with limited adaptation options which have prompted intervention measures such as the distribution of food aid, remittance from their relatives in the form of cash inflows from within and diaspora, index-based livestock insurance covers, partnerships and collaborative governance structures, conflict resolution initiatives and capacity building, livestock mix, sale of artefacts, beekeeping, employment opportunities in other sectors and establishment of structured markets where other forms of merchandise other than livestock are traded as well to enhance their resilience.

**Keywords:** Arid and Semi-Arid Lands, Social-Ecological System, cultural practices, pastoralism and climate patterns

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## **LIST OF ABBREVIATIONS/ACRONYMS AND SYMBOLS**

- ASALs** - Arid and Semi-Arid Lands
- CIDP** - County Integrated Development Plan
- CHIRPS** - Climate Hazards group Infra-Red Precipitation with Stations
- FAO** - Food and Agriculture Organisation
- GDP** - Gross Domestic Product
- GIS** - Geographic Information System
- GPS** - Geographical Positioning System
- GoK** - Government of Kenya
- ICPAC** - IGAD Climate Prediction and Application Centre
- IGA** - Income Generating Activities
- IK** - Indigenous Knowledge
- IPCC** - Intergovernmental Panel on Climate Change
- IUCN** - International Union for Conservation of Nature
- KFS** - Kenya Forest Services
- KII** - Key Informant Interviews
- KMD** - Kenya Meteorological Department
- KNBS** - Kenya National Bureau of Statistics
- KRCS** - Kenya Red Cross Society
- KWS** - Kenya Wildlife Services
- LULC** - Land Use and Land Cover
- MAM** - March-April-May
- NACOSTI** - National Council of Science and Technology Innovation
- NDMA** - National Drought Management Authority
- OND** - October-November-December
- PES** - Payments for Environmental Services
- RCMRD** - Regional Centre for Mapping of Resources for Development
- RS** - Remote Sensing

## GLOSSARY OF TERMS

**Analogous** is similarity of the biophysical environment, socio-economic activities and cultural context (Morara *et al.*, 2014).

**Adaptation** is defined as adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2014).

**Adaptive capacity** is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2014).

**Biodiversity** is the presence of a variety of all forms of life existing on Earth including plants and animals. This is inclusive of micro-organisms and their genetic make-up and the ecosystems they form.

**Biocultural** denotes a people's long-established rights, in accordance with its traditional laws, to steward its natural resources, i.e. a collective right to carry out traditional stewardship *vis-à-vis* nature (Bavikatte and Bennett, 2015).

**Classification** here refers to 'image classification' - the process of assigning a land cover class (or class probability) to each image pixel from Landsat images.

**CHIRPS** here refers to Climate Hazards group InfraRed Precipitation with Station data is a 30+ year's quasi-global precipitation dataset. Spanning 50°S-50°N (and all longitudes), starting in 1981 to near present. CHIRPS incorporate 0.05° resolution satellite imagery with *in situ* station data to create gridded precipitation time series (Funk *et al.*, 2015)

**Climate Change** refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period - typically decades or longer (IPCC, 2014).

**Community resilience** is a functionality of the physical environment, physical and psychological health, the governance structures, network of trust and communication, flexibility and redundancy of the community (Levy *et al.*, 2017).



**County**, according to the Constitution of Kenya, 2010, it is a planning unit following the re-organization of Kenya's national administration headed by a governor; there are 47 counties in Kenya whose size and boundaries are based on the 47 legally recognized districts in Kenya at the time of independence.

**County Integrated Development Plan** is a document that guides various development projects in line with the national Medium Term Plans and also provides the baseline for monitoring the progress of development projects.

**An ecosystem** is a natural unit composing of both non-living and living factors whose interaction leads to a self-sustaining system; this is a dynamic complex of plants, animals and microorganism communities and their non-living environment interacting as a functional unit.

**Exposure** is the level to which a system is exposed to climatic extremes.

**Food insecurity** is a situation where the food production is not able to sustain the population or lack of adequate food to feed the population or deficiency in food to take care of population dietary requirements.

**Food security** is a state where people at all the times have the physical and economic ability to access adequate, safe and nutritious nutrition to fulfil their dietary needs and their nutrition choices for active healthy lives.

**Geographic Information System** is a software/tool for creating, analysing and managing spatial and temporal data and storing their associated attributes.

**Household** is a social/domestic unit consisting of one or more people occupying a housing unit or same dwelling and also share meals or living accommodation or same eating arrangement and may consist of a single-family or a group of families

**Integrated Approach** is an all-inclusive process involving relevant agencies to bring about the necessary response actions; it also takes into account the prior conditions, problems and resources available for development.

**Institutional Framework** refers to formal regulations, laws or procedures. It also incorporate customs, norms and informal conventions which shape socio-economic activity, service provision and behaviour.

**Indigenous Knowledge** is the complex body and system of knowledge, representations and practices maintained or developed by indigenous people around the world, depicting a wealth of experiences or interconnection with the natural physical environment and transmitted verbally from one group to the next.

**Social-Ecological System** is a system of people and natural-based structures, emphasising that humans must be seen as part, not apart from nature (Berkes and Folke, 1998).

**Land cover** consists of the observed biophysical phenomenon on the Earth's surface that includes natural vegetation and artificial features.

**Land Use and Land Cover** is a long-term satellite monitoring of terrestrial biomass through remote sensing to analyse spatial-temporal changes in land uses.

**Natural resource** is a material obtained from the earth's environment made available by nature for our survival needs e.g. pasture and water.

**Population density** is persons per square kilometre or mile.

**Population increase** is the total rise resulting from the interaction of birth, death and migration in a population in a specific location of a given area.

**Population size** is a group of people, comprising of males and females in a particular location or area e.g. district, county.

**Remote sensing (RS)** is the gathering of information on a phenomenon or an object without making physical contact, usually through a satellite.

**Resilience** is the amount of pressure a system can undergo without changing state (IPCC, 2014).

**Sensitivity** is the degree to which a system is affected either adversely or beneficially by climate-related stimuli. The effect may be direct (e.g. a change in crop yield in response to a change in

the mean, range or variability of temperature or indirect e.g. damages caused by an increase in the frequency of coastal flooding due to sea-level rise (IPCC, 2014).

**Vulnerability** is the level to which a system is susceptible to or unable to cope with adverse impacts of climate change, including variability and extremes and is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2014)

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background

The rapidly changing climate has been experienced across the globe (IPCC<sup>1</sup>, 2014). These shifts are characterized by harsh impacts on natural systems that pastoral livelihood system depends on (Markalis, 2004; IFAD<sup>2</sup>, 2009; Morrison *et al.*; 2018). According to IPCC (2014) report, natural systems consist of food and human security inclusive of human health. These three attributes are all sensitive to changing climate. The Earth's surface has increasingly turn out to be warmer, especially in the last three successive decades, but the years 1983-2012 were worst hit by the rising temperatures in the Northern hemisphere. These common risks that threaten natural systems included heatwaves, droughts, floods, cyclones and wildfires.

Africans are mostly adversely impacted by the climate change (IPCC, 2007, 2014; World Bank, 2013; Filho *et al.*, 2017) because of their heavy reliance on rain-fed production system (Nobenbaert *et al.*, 2013; Lopez-Carr and Burgdorfer, 2013). In the last decade, Africa has faced food insecurity situation attributed to the impacts of climate shift (FAO<sup>3</sup>, 2010; Marius, 2012; IPCC, 2014). The East African region has not been spared from the adverse effects of shifting climatic patterns. It has suffered low economic capacities and social instabilities which have been attributed to heavy reliance on natural resource-based livelihoods such as livestock rearing and cultivation agriculture (Cooper *et al.*, 2008).

The country Kenya is located in the Eastern part of the African continent. The country is mostly Arid and Semi-Arid Lands (ASALs) with over 80 per cent of its landmass having aridity features (Mwang'ombe *et al.*, 2011). These Arid and Semi-Arid Lands (ASALs) areas harbour the largest number of herds (GoK<sup>4</sup>, 2012) having an estimated livestock population of about 13 million cattle, 25 million goats, 14.9 million sheep, 1.7 million donkeys and 2.9 million camels (KNBS, 2019).

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<sup>1</sup> "Intergovernmental Panel on Climate Change"

<sup>2</sup> "International Fund for Agricultural Development"

<sup>3</sup> Food and Agriculture Organization

<sup>4</sup> Government of Kenya

Thus, the ASALs predominance with the livestock sector forms a key economic pillar for most of the households' income and employment (Kaimba *et al.*, 2011; Kiriimi *et al.*, 2013).

Kajiado County is predominated by the Maasai community which is one of the largest pastoralists groups in Kenya according to County Integrated Development Plan (CIDP 2018-2022<sup>5</sup>). The community has attempted to adapt to the shifting climatic patterns though they are still faced with a looming threat to their livelihood system due to the rising temperatures (Said *et al.*, 2017) which leads to high evaporation rates that result to drier conditions that cannot sustain vegetation regeneration (Adams *et al.*, 1998; Oxfam<sup>6</sup>, 2008; Schwartz *et al.*, 2005).

Natural resource base has been dwindling in the County (Behnke, 2000), especially indigenous pastures which have withered, and led to emaciation or death of livestock in the area (Western, 1997; O'Malley, 2000; Lopez-Carr and Burgdorfer, 2013). In spite of the shifting climatic patterns, the Maasai community has maintained nomadic pastoralism yet traditional seasonal movement of livestock has been curtailed due to changes in land use patterns and socio-cultural dynamics. The Maasai pastoralists have faced many hurdles that have led to the escalation of food insecurity levels in the County (Nori and Davies, 2007; Bobadoye *et al.*, 2016) hence the need for this research.

## **1.2 Problem Statement**

Kajiado County is densely occupied by the Maasai pastoralists and they are highly dependent on natural resources (Gregory *et al.*, 2005; Oxfam, 2008; Said *et al.*, 2017). Pastoralism, their dominant livelihood system, is under threat due to the shifting climatic patterns. The area has experienced rising temperatures (New, 2015; Said *et al.*, 2017) and IPCC (2014) reported that a temperature increase that exceeds 1.5°C can lead to a significant loss of terrestrial biomass. Furthermore, Sharma *et al.* (2014) argues that the rise in temperature is associated with drier condition and landscape degradation.

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<sup>5</sup> County Integrated Development Plan 2018-2022

<sup>6</sup> Oxford Committee for Famine Relief

MoALF<sup>7</sup> (2017) reported increased aridity in Kajiado County. The Report further reiterates that drought episodes had increased in the area in the last decade and that livestock deaths were in excess of 70 per cent in most parts of the county due to the 2009 drought. This information is similar to the one provided by Hugo and Mugalavai (2010) who indicated that the 1999-2000 drought had one of the highest mortality rates of cattle and shoats<sup>8</sup> at 50 per cent and 20 per cent respectively. Walker *et al.* (2004) and Lopez-Carr Burgdorfer (2013) concur that there were massive losses of livestock and severe food shortages in the area. Furthermore, other authors have indicated that the area had experienced increased drought episodes in recent times (Western, 1989; O'Malley, 2000; Nyariki *et al.*, 2009 and Kirimi *et al.*, 2013).

The dwindling natural resources have contributed to the massive livestock deaths and widespread food insecurity which has rendered the community vulnerable (Nobenbaert *et al.*, 2013; López-Carr *et al.*, 2014). Similarly, (Mace, 1991; Behnke *et al.*, 1993; Behnke, 2000; Galvin, 2009), reported changes in rainfall patterns in the area has resulted in receding water levels as the area depends on rainfall for surface water recharge (Campbell and Olson, 1991). As such, the County has experienced retardation in vegetation growth and low production (Ashton, 2002; Mukuna *et al.*, 2015). However, knowledge gaps exist as to whether there is a shift in climate patterns (Milly *et al.*, 2008) hence it was important to carry out climate trend analysis to offset this incomplete understanding.

The vast community land which the Maasai pastoralists used to enjoy has been constrained to a point where mobility<sup>9</sup> has been compromised. This has been exacerbated by the weak land tenure system that is prone to land grabbing. Therefore, significant areas of land that was initially registered under communal land ownership have been converted to private ownership (Raleigh and Urdal, 2007). Mobility, an intervention which enabled the Maasai pastoralists to cope with effects of shifting climatic patterns has been curtailed by private landholding (Campbell and Olson, 1991; Krisjanson *et al.*, 2002; Mwangi and Dohrn, 2006; Lesorogol, 2008) yet the Maasai

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<sup>7</sup> Ministry of Agriculture, Livestock and Fisheries

<sup>8</sup> Shoats means sheep and goat

<sup>9</sup> Whereby livestock roam freely while setting aside of lowlands for the wet season and elevated land for dry season grazing respectively

community rely exclusively on natural systems that include the open space for their provisions and production needs (ILRI<sup>10</sup>, 2006; KNBS<sup>11</sup>, 2009; Mwang'ombe *et al.*, 2011; NEMA<sup>12</sup>, 2011).

The Maasai pastoralists have continued to sell off their land for quick cash. Krisjanson *et al.* (2002) and Mwangi (2006) noted that there is instant reward accrued from land sales which has created the urge for cash, as large tracts of land are subdivided. Selling of land is a short term coping mechanism since it is less reversible and depletes households of critical resources thus increasing their vulnerability (Gichangi and Gatheri, 2018). Molua and Kagwanja (2015) and Kinyenze and Irungu (2016) also noted that there is a push for land subdivision associated with the land squatters problem. Other studies have argued that the County has of late experienced less per capita acreage of land per household as the rapidly growing population compete for resources (Galaty, 1994; Homewood *et al.*, 2004; Burnsilver, 2007; Leserogol, 2008; Silvestri *et al.*, 2012 and Nkedianye *et al.*, 2009). The reduction in land acreage per household and exclusivity in land use have heightened resource-based conflicts in the area (Mace, 1991; Behnke *et al.*, 1993; Behnke, 2000; Galvin, 2009; Morara *et al.*, 2014; Molua and Kagwanja, 2015). Bobadoye *et al.* (2016); Swamy (2013) and Ozor *et al.* (2012) reported that the emerging land tenure systems might transform the Maasai's pastoral Social-Ecological System to the point of losing key biophysical features yet they rely on open space within their area to cope with climate shifts. Similarly, Ozor *et al.* (2012) and Sharma *et al.* (2014) stated that the County has experienced uncertainty and perpetual disequilibrium in its natural resource base yet previous studies have not coherently addressed transformation in this pastoral Social-Ecological System which necessitated the need for mapping natural resources to inform the incomplete understanding.

The Maasai community have all along thrived in communal land setting which has facilitated mobility, flexibility and opportunistic grazing. Mobility has allowed them to move with their herds to areas with under-utilized forage during drought episodes (Hobbs *et al.*, 2008; Little *et al.*, 2001; Galvin, 2009) and it explains the reason as to why they have been able to undertake interventions which have enabled them to sustainably manage and utilize key natural resources within their territory (Reid *et al.*, 2008). UNDP (2013) and Campbell *et al.* (2005) opine that the maintenance or restoration of pastoral Social-Ecological System requires the development of sustainable coping

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<sup>10</sup> International Livestock Research Institute

<sup>11</sup> Kenya National Bureau of Statistics

<sup>12</sup> National Environment Management Authority

and adaptation strategies that will help address shifting climatic patterns overlaid by externalities such as land-use change patterns. GECG<sup>13</sup> proposes cultural perspectives as an integral management aspect in pastoral Social-Ecological System (Shiferaw *et al.*, 2017). In spite of this, the Maasai community is now facing bottlenecks due to the negative impacts of climate change which is breaking down social networks which have been built over a long time. As such, it has become difficult for them to uphold on to cultural practices such as *Enuoto*<sup>14</sup> (Davies and Noris, 2007Galvin, 2009). Therefore, they are still experiencing low herd numbers and livestock production (Ericksen *et al.*, 2013; Bobadoye *et al.*, 2016). This observation is similar to that of (Nassef *et al.*, 2009) who reported low livestock production levels in the area. Further, (FAO, 2010) indicated that the Maasai community have less access to habitual pastoral grazing space leaving them food insecure. Their observation was supported by Galvin (1992) and Sellen (1996) who asserted that alternative food products were too costly for the community to afford and that has prompted external interventions such as enhanced food and nutritional programmes. The dwindling natural resources (Kihila, 2015) implies that the Maasai community will be unable to adequately sustain pastoralism yet their responses have been inadequate, incoherent and fragmented (Mussa *et al.*, 2017). Thus, the need for this research to assist the Maasai community to identify sustainable intervention measures to enhance their resilience.

### 1.3 Research Questions

The study, through the research questions below, evaluated the past climate trends and Land Use and Land Cover Changes and their implication in the sustenance of livestock production by the Maasai community in Kajiado County.

- i) What is the temporal distribution of precipitation and temperature and how does this affect pastoral livelihoods in Kajiado County?
- ii) What are the Land Use and Land Cover Changes and how have they affected pastoral livelihoods in Kajiado County?
- iii) What are the adaptation strategies to enhance resilience to the pastoral Social-Ecological System to climate and land use transformation?

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<sup>13</sup> Global Environmental Conservation Guidelines

<sup>14</sup>Enuoto-ceremonial cycles performed by the Maasai community as the young warriors' transition to eldership and the event symbolized by shaving the Morans but only done when the fields are green



## 1.4 Main and Specific Objectives

The core objective of this research was to investigate the impacts of climate change and land-use changes on the pastoral Social-Ecological System to inform on adaptation and resilience strategies in Kajiado County, Kenya.

The specific objectives for this study were to:

- i) Determine the historical climate trend and its impacts on pastoral livelihoods in Kajiado County, Kenya.
- ii) Evaluate the pastoral Social-Ecological System and its influence on pastoralists' livelihood in Kajiado County, Kenya.
- iii) Determine adaptation strategies to enhance the resilience of the pastoral Social-Ecological System to climate change and land use transformation in Kajiado County, Kenya.

## 1.5 Justification and Significance

### 1.5.1 Justification

In Kenya, 29 out of the 47 counties are categorised as Arid and Semi-Arid Lands (ASALs) and they are mostly inhabited by pastoralists (MoD<sup>15</sup>, 2018). These ASAL counties support at least 50 per cent of the livestock population in the Country (KNBS, 2009). Kajiado County is not an exception for it is among the ASAL counties and it is mostly inhabited by the Maasai's whose main economic activity is pastoralism (CIDP<sup>16</sup>). FAO (2010) reported that the unpredictable and non-equilibrium climate conditions in the ASALs could adversely affect the livestock sector. This information is similar to that reported by Erickson (2010) and Said *et al.* (2017) who reported that Kajiado County has experienced climate shifts which have led to multiple production risks (Cooper *et al.*, 2008; Kirimi *et al.*, 2013; Pal and Eltahir, 2015; WHO, 2014). Therefore, it was important to determine the historical climate trends to have an improved understanding of the climate system of the area that would possibly inform the future preparedness of the vulnerable Maasai community.

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<sup>15</sup> Ministry of Devolution

<sup>16</sup> CIPD-County Integrated Development Plan

Land use transformation in the dryland landscape has been exacerbated by alternative investments such as an expansion of irrigated agriculture and infrastructure development. These developments have restricted open space and seasonal movement of livestock (Reid *et al.*, 2008). These changes in land use patterns are not compatible with pastoralism and have resulted in landscape transformation (Raleigh and Urdal, 2007). The emerging land tenure systems have been influenced by weak land policies overlaid by low education levels and financial incapacity among the Maasai pastoralists (Thornton *et al.*, 2006; O'Brien and Leichenko, 2007). This push for land privatization and subdivisions (Krisjanson *et al.*, 2002; Filho *et al.*, 2017; Little *et al.*, 2001; Hobbs *et al.*, 2008; Galvin, 2009) has created land-use exclusivity which is not in harmony to pastoral social-ecological setting and has curtailed the free movement of herds between dry and wet areas (Reid *et al.*, 2008). It has, therefore, contributed to the destructive tendency such as overgrazing which has created multiple production risks in the area (Homewood *et al.*, 2012). This statement was also reported by Catley *et al.* (2013) who reported landscape degradation yet the Maasai livelihood is highly dependent on natural resources whose status is currently inaccurate. Thus, there was a need for mapping the area to ascertain the status of these natural resources as a benchmark for co-management, planning and policy formulation.

Livestock sector forms a central role in the cultural, social and spiritual well-being of the Maasai community (League of Pastoral People, 2009). Sinclair and Pech (1996) noted that there are comparatively large stocks of livestock within the Maasai community but they are facing a threat due to the climatic shift and restriction attributed to transformations in land-use patterns. Therefore, it is eminent that their livestock herds could decline if urgent interventions meant at doubling the current efforts in livestock production are not enforced. This is coming at a time when there is increased demand for animal protein. Gregory *et al.* (2005) reported that there should be more interventions in livestock ventures to keep up with the increasing demands for animal proteins. This demand has continued to rise worldwide with a projection of 8 billion people consuming animal protein by the year 2020 (World Bank, 2014).

### ***1.5.2 Significance***

Pastoralism supports the economy and livelihood of a large population in the marginal areas of Sub-Saharan Africa yet it is at risk due to climate shifts (Nyariki *et al.*, 2009; IUCN<sup>17</sup>, 2010; Kirimi

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<sup>17</sup> "International Union for the Conservation of Nature"

*et al.*, 2013). The sector sustains approximately 20 million pastoral households and it is source of income to a large population across the globe. Besides, approximately 200 million peasant farmers in Africa, Latin America and Asia rely on livestock sector as a source of livelihood (World Bank, 2014). The contribution of livestock production towards the world's food stock is enormous hence any form of disruption in the form of a shift in climate patterns will render most parts of the world food insecure (World Bank, 2008). In Kenya, the livestock sector supplies significant amounts of animal proteins, namely: meat and milk, which are important dietary components to the majority of its citizens. Thus, a viable livestock venture has an integral role in attaining Kenya's Vision 2030 on improved food security.

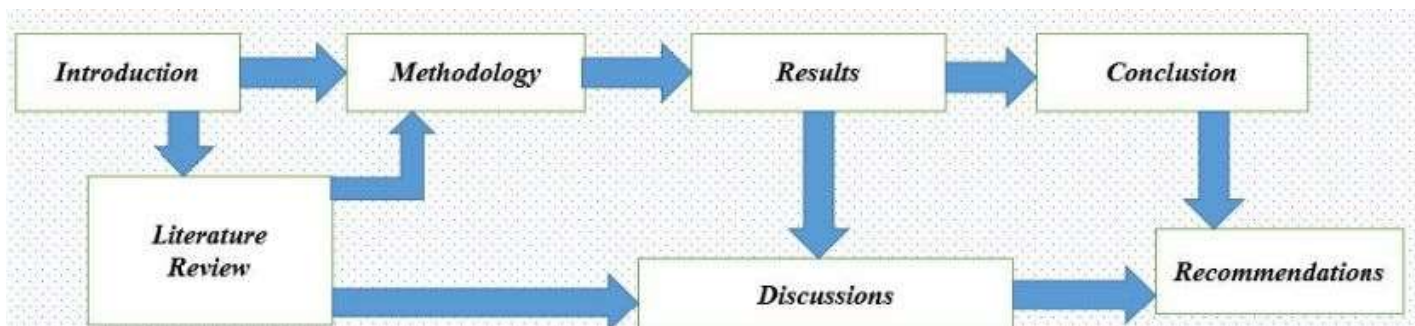
Sustainable pastoralism requires an in-depth knowledge of the climate system which includes prediction and seasonal forecasting (Said *et al.*, 2017). Ostrom (2009) noted that the sustenance of pastoral Social-Ecological System requires in-depth knowledge and a complete understanding of key interactions in the natural resource system. The Maasai community has utilized their indigenous knowledge but this might be inadequate, taking into consideration the fast changing context of climate shifts (Shiferaw *et al.*, 2017). As such the adverse impacts of unpredictable climate pattern is a reason for concern as it has distorted traditional seasonal movement of livestock (Mukuna *et al.*, 2015). Moreover, it has made it difficult for the Maasai pastoralists to understand seasonal patterns hence they have been left more exposed and confused (Walker *et al.*, 2004). Mobility is driven by pasture demand and as such seasonal failure has made it difficult for them to adequately respond to some of the emerging risks facing them. Therefore, the capacity gap of the climate system has turned out to be a threat to pastoral livelihood despite their rich traditional knowledge and insights (UNDP, 2013). This information concurs with that of (Xiao *et al.*, 2018) who reported that traditional knowledge enabled pastoralists to attain societal and ecological resilience. Therefore, the push for sustainable ecology cannot be complete without traditional institutions which have played a crucial role in survival in the dryland ecosystem. Bennette (2015) also reported the importance of understanding the cultural perspective in resource management which denotes "*a community's long-established rights in accordance with their customary laws, to steward its land, water and natural resources*" This opinion is supported by (Sharma *et al.*, 2014) who said that indigenous institutions have sustained natural systems and protected them from wanton destruction.

## 1.6 Scope and Limitations

The choice of Kajiado County was guided by the existence of coherent and significant numbers of indigenous Maasai people. These Maasai are predominantly nomadic pastoralists (KNBS, 2019). In addition, they have been known for their unique traditional texture that they have used to manage key natural resources and maintain them over time. These people are still practising nomadic pastoralism despite the threats posed by the shifting climate patterns and increased land subdivision. An in-depth study involving the locals was purposively carried out in Loitokitok area of Kajiado South and it targeted eight analogous villages: Mabateni, Inkoisuk, Nasipa, Olng'osua, Isinet, Kasesirua, Inshura and Namelok who practice pastoralism. The study encountered hurdles such as the expansiveness of the area and difficult terrains that made field visits tedious. The resources were also limited thus the study opted for the use of Google Earth to validate the land cover types which included grassland, forestland and shrubland without putting into consideration the invasive species which had infested significant areas of the entire landscape.

## 1.7 Layout of the Thesis

The content of this thesis is organised in seven chapters. The first chapter is the introductory part and it looks at the background of the study. Literature review is in chapter two and it reviews similar studies while chapter three focuses on study area, data and methods. Chapter four, five and six entail detailed results, discussions and conclusions according to the objectives of the study while chapter seven entails the conclusion and recommendations that points out the key findings and the way forward.



**Figure 1.1:** Logical flow showing the thesis layout

**Source:** Author

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter highlights relevant literature on dynamics of pastoral Social-Ecological System in response to climate change, population increase, human resettlement, economic development, urbanization and changes in land tenure systems from global, regional and national perspectives. It then narrows down to establish relationships between climate variables and pastoral Socio-Ecological System and how they have influenced adaptation strategies in enhancing resilience in Kajiado County.

#### 2.2 Climate Trends

Pastoralists exhibit high poverty indices and this has been exacerbated by the rapidly shifting climatic patterns (World Bank, 2016; IPCC, 2014). UNDP (2013) reported that pastoralists have become more vulnerable and their situation has been attributed to climate shifts. The Maasai pastoralists in Kajiado County are no exception according to the MoALF<sup>18</sup> (2017) Report. The Report reiterates the need for the local Maasai pastoralists to have an improved understanding of climate science to enable them to have enhanced preparedness to the negative effects of the rapidly shifting climatic patterns. Accurate predictions of seasonal forecast will adequately prepare the Maasai community for climate uncertainties which are likely to increase the risks and exacerbate the fragile conditions in their regions.

Scientific consensus on the future climate predictions is that a huge proportion of the dryland ecosystem will experience severe drought and flood episodes to the point of threatening pastoralism (IPCC, 2007; Thornton *et al.*, 2011; Erasmus *et al.*, 2002). Climate is a key attribute in livestock production for it influences spatial distribution and availability of natural resources (Erickson, 2010). It is paramount to note that the rains of the previous production season affects pasture regeneration in the subsequent season. This opinion is comparable to that reported by (Erickson, 2010) who indicated that the seasonal rain failure is an indicator of drought. This implies that the vegetation cover responds to moisture stress by shrinking which leads to death of

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<sup>18</sup> Ministry of Agriculture, Livestock and Fisheries

livestock as a result of depleted pastures as is the case in Kajiado County which has experienced unpredictable climatic patterns Galvin *et al.* (2004). Those occurrences have negatively affected pasture regeneration leading to low livestock yields (Mace, 1991; Behnke *et al.*, 1993; Behnke, 2000; Said *et al.*, 2017).

Climate shifts have become more evident in the region and it has led to the vulnerability of the Maasai pastoralists. Pastoral livelihood system is under threat and it has been exacerbated by climate change overlaid by anthropogenic activities such as land subdivision, an increase of private land ownership and change in land use pattern (Mukuna *et al.*, 2015). Intergovernmental Panel on Climate Change (IPCC, 2014) reported that climate change has contributed to ecological degradation in the ASALs worldwide. The common agreement is that Africa is susceptible to the onset of climate change with a projected temperature rise of 1°C-2.5°C across the entire globe in the next 30 years (Boko *et al.*, 2007). Similarly, IPCC (2007) also reported rising temperatures and the report associated such warmer temperatures with lower yields, widespread food insecurity and loss of biodiversity. This finding agrees with that of the UNDP (2013) Report which stated that people inhabiting pastoral Social-Ecological System are in such dire situation and they will have to exploit whatever is available within their ecosystem to survive.

Africa has experienced severe drought and flood episodes (Galvin *et al.*, 2004). Such occurrences have had adverse effects on pastoralism, the main economic mainstay in the ASALs, having in mind that pastoral livelihood system is highly dependent on rain-fed production system (Nyariki *et al.*, 2009). Changes in the climatic patterns have negatively affected livestock productivity (Markalis, 2004; Catley *et al.*, 2013). For instance, the shift in vegetation cover (Reynolds *et al.*, 2007) with the decline in palatable pastures has led to multiple production risks as some of the affected pastoralists are on the verge of losing their livelihood system if timely intervention measures are not put in place (Birch and Grahn, 2007).

The rapid rate at which these climatic variations are taking place is a reason for concern. Just like other ASALs worldwide, Kajiado County is facing a transformation of its key landscape features following the extinction of certain species (Opiyo *et al.*, 2011) yet those species have been used in the context of indigenous knowledge to accurately influence the prediction of the weather or seasons. Therefore, without them, climate-related uncertainties could prevail and as a result, threaten the sustenance of pastoral livelihood system. Ozor *et al.* (2012), opines that the

unpredictable climatic patterns have contributed to widespread food insecurity across the ASALs and Kajiado County is not an exception. According to Osano *et al.* (2013), the Maasai community who have been known to be food secure are now food insecure and are increasingly becoming vulnerable to additional production risks (Ouma *et al.*, 2001; Nori and Davies, 2007). Such calamities have elicited varied perceptions on the impacts of climatic variations. Meanwhile, the community remains misunderstood by outsiders who perceive pastoralism as a poor land use method with low economic value (Folke *et al.*, 2010) hence the timely need for the study to amalgamate the fragmented cultural perspectives.

### **2.3 The Pastoral Systems, Resilience and Adaptation**

Resilience has been incorporated in pastoral Social-Ecological System research (Berkes *et al.*, 2003; Folke, 2006; Reid *et al.*, 2008; Gunderson and Holling 2002). Resilience is defined as “the capacity of a system to absorb disturbances and reorganize to retain essentially the same function, structure, identity and feedbacks” (Walker *et al.*, 2004). Gunderson and Holling (2002) and Berkes *et al.* (2003) opine that a resilient Social-Ecological System will not solely maintain its function, but may also gain from disturbances by reorganising to further improvement in resilience. Nevertheless, resilient livelihoods in the Social-Ecological System may be promoted by the government or Non-Governmental Organizations (NGOs) but may be perceived by the community as radical and undesirable cultural change (Crane, 2011).

Resilience building is a concept widely spoken about in the context of climatic shift. According to USAID (2012) and UNDP (2013), resilience has been defined as the “*the ability of people, households, communities, and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth*”. Thus, resilience entails human, environment agencies, socio-economic and political structures of systems (Obrist *et al.*, 2010; Tanner *et al.*, 2015). The complex environmental challenges facing the dryland ecosystem overlaid by climate change necessitates the need for an improved understanding of resilience based on the pastoral Social-Ecological System and the inherent relationships between the variables and processes across several scales temporally and spatially (Muriel and Nightingale, 2011). Therefore, in realising resilience, there is a need for systematic evaluation of the available natural resources (Schluter *et al.*, 2012).

The interplay between the community and the natural environment in the pastoral Social-Ecological System should improve both the societal and ecosystem resilience (Obrist *et al.*, 2010). The integration of human-environment relation makes resilience thinking more clear within the sustainable livelihood systems. In conclusion, resilience in the “Arid and Semi-Arid Lands” (ASALs) should address among other factors the climatic characteristics, economic status and social networks (Sparanza *et al.*, 2014; Tanner *et al.*, 2015). This argument is in agreement with Samuels *et al.* (2008) and Adger (2003) who advocated for enhanced resilience through the incorporation of indigenous knowledge while recognizing its integral role in attaining social and ecological resilience.

The Maasai pastoralists have somehow managed to uphold their cultural perspectives which “denotes a community’s long-established rights, in accordance with its customary laws, to steward its land, water and natural resources”. (Bavikatte and Bennett, 2015). However, concerted external pressures are resulting from the shifting climatic patterns within their habitual pastoral living space (Galvin *et al.*, 2001; Birch and Grahn, 2007; Little *et al.*, 2001) which have influenced lifestyle changes (Mwangi and Dohrn, 2006; Berteaux and Stenseth, 2006; Filho *et al.*, 2017). The resultant socio-cultural adjustments could trigger non-compliance to their traditional governance structure. Yet, traditional stewardship has been integral in the sustenance of pastoral Social-Ecological System which has contributed immensely to their resilience.

The Maasai have solely depended on pastoralism as a single economic activity despite the anticipated adverse impacts of climatic shifts and variability (KNBS, 2009). Similarly, Behnke *et al.* (1993) noted that they have maintained pastoralism as their dominant livelihood system. These large herds of livestock under their control have been attributed to their cultural heritage which has been passed on over generations while sustaining natural resources in an attempt to sustain their livelihood (Nyong *et al.*, 2007). Cultural practices have been passed on to subsequent peers through channels such as; age sets, ethnic clusters and wise men over time (Mudimbe, 1998). In spite of this, the Maasai pastoralists have been left out in planning and decision making on matters regarding their environment and economic livelihood (Mutu, 2017).

According to Plummer and Armitage (2010), adaptive capacity is “the ability to cope with disturbances and being able to respond to change”. Adaptive capacity might vary in a Social-Ecological System but it is important to note that a community with multiple resources may adapt

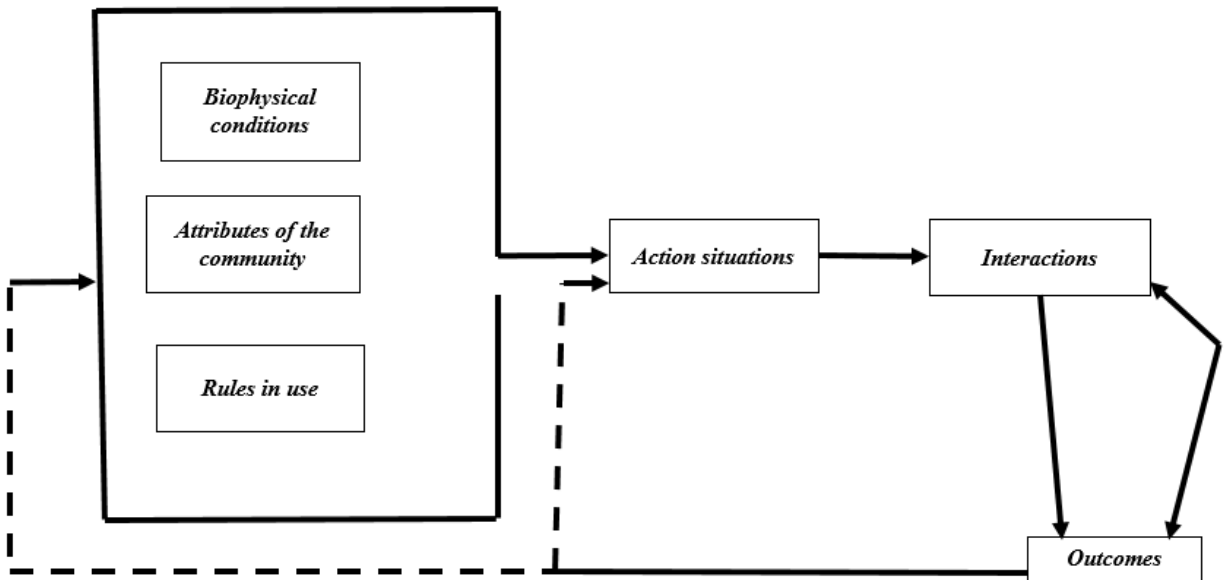


better to change compared to one with limited resources. Therefore, a multi-species pastoral landscape can easily maintain productivity despite the climate shifts. According to (Rammel *et al.*, 2007), adaptation is a continual, interactive process over time. While it is necessary that the society, particularly the Maasai pastoralists, follow pursuit and adapt to climate change, the ability to adapt and the option available for adaptation might be limited due to how the social-ecological landscape was developed. The Maasai pastoralists have managed their activities within a single local ecosystem context through community-based resource management system (Leach *et al.*, 1999) and adaptive co-management (Olsson *et al.*, 2004). Sharma *et al.* (2014) and Ellis and Swift (1988) are of the same view and they reported that the Maasai governance system is based on strong social networks whose benefits include improved ecological equilibrium. Walker *et al.* (2004) and Armitage *et al.* (2009) noted that pastoral Social-Ecological System should be holistic and responsive to complexity in policies and governance that support system resilience. Importantly, there must be stakeholder engagement and creation of consensus around initiatives before they are implemented as adaptation strategies across many dimensions of the Social-Ecological System. However, Turner (2014) opine that some social ecological hurdles occur at an extensive spatial scale which requires organizations with broad jurisdiction covering large geographical scales to intervene to regulate, such as migration of livestock under transhumance.

#### **2. 4 Pastoral Social-Ecological System and Livelihoods**

There are enormous challenges on the pastoral Social-Ecological System arising from landscape conversion and climate change. Ostrom (2005, 2007, 2009), stated that we can build upon the Social-Ecological System framework to organize, diagnose, describe and prescribe inquiry on natural resources. Further, Hruska *et al.* (2017) opined that the pastoral Social-Ecological framework makes it possible for one to identify cross-system feedbacks to be in a position to explain the otherwise puzzling outcomes. This framework consists of social-ecological attributes and processes that interact each other in profound ways (Hruska *et al.*, 2017). More importantly, it scrutinizes drivers of transformation and causes of specific outcomes using key attributes such as resilience, adaptability and transformability to decide their future trajectories (Hruska *et al.*, 2017). The main gains of this framework is that it enhances the ability for correct social policies that causes negative ecological outcomes, it also helps to attain the larger objective of ecological restoration in ways that sustain, rather than hurt pastoralists (Hruska *et al.*, 2017). In this regard,

Social-Ecological System design forms a holistic framework to cope with complexity and at the same time attain desirable yields as shown in Figure 2.1.



**Figure 2.1:** *Generic Social-Ecological Framework*

Source: Adopted from Ostrom, 2011

The pastoral Social-Ecological System has been likened to human-natural systems which reflect both the society and ecosystems and their distinct internal dynamics and reactions in response to each other (Hruska *et al.*, 2017). Lie *et al.* (2007) and Turner *et al.* (2003) noted that responses to the problems are sometimes unpredictable thus, it is important to comprehend how human use affects the capacity of ecosystems for it to sustainably support their needs. The pastoral Social-Ecological System entails a comprehensive multi-disciplinary approach which has an in-depth knowledge of social-ecological components including interactions and processes that shapes pastoral conditions. These components are inclusive of social, economic, cultural and political. These attributes are crucial especially to communities within the pastoral system. According to Ostrom (2009), environmental hurdles arise from letdowns in social practices as much as it is caused by ecological processes. Having recognised this, there is a need for a similar framework

for holistic understanding of the drivers that lead to enhancement or deterioration of natural systems.

The pastoral Social-Ecological System gives a framework for analyzing pastoral dynamics and identifying mediations that can increase pastoral sustainability. Besides, it support production of the desired goods and services. Moreover, the pastoral ecology study has conventionally focused on grazing managements and ecological indicators but it does not give much consideration to the needs of the herders (Hruska *et al.*, 2017). Therefore, there is limited success at connecting social, cultural, political to ecological outcomes (Brunson, 2012). According to (Wangui, 2008), exclusively technical intervention as a method of pastoral sustainability often fails. She justified this sentiment by using an illustration involving the introduction of improved livestock to replace the local breeds as a measure of improving livelihood which resulted in unintended consequences namely: financial risks, altered grazing arrangements and gender roles, increased in labour needs and diminished income for women. Thus, the improvement of livestock breeds to enhance the resilience of the Maasai pastoralists may have achieved little when it comes to the alleviation of pastoralists overarching problems such as inadequate markets, crop encroachment, land grabs and climate change.

Humans alter natural systems in pastoral Social-Ecological System to increase the accrued ecosystem benefits (Reid *et al.*, 2008). According to (Hruska *et al.*, 2017) some changes are drastic such as tilling for crop cultivation but others are less noticeable such as vegetation alterations over time which comes as a result of extensive livestock foraging. Human systems respond to ecosystem changes in diverse ways, as with the demographic, policy and economic responses to drought, wildfires and deforestation. Therefore, pastoral administration cannot afford to overlook the Maasai community's dimensions if the anticipation is to contribute solutions to the real-world problems.

The Arid and Semi-Arid Lands (ASALs) occupy 80 per cent of Kenya's landmass and in terms of population approximately 20-25 per cent of the country's population have been settled in the dryland ecosystem (ILRI<sup>19</sup>, 2006). This is a significant proportion of landmass from which pastoral communities derive ecosystem benefits (Homewood *et al.*, 2009). It is imperative to note that in

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<sup>19</sup> International Livestock Research Institute

the recent past, the ASALs have experienced high levels of biophysical transformation such as fixed settlement patterns, declining ecosystem services and dwindling water resources (ILRI, 2006; O'Brien and Leichenko, 2007; Mearns and Norton, 2010) and Kajiado County is no exception. It has experienced degraded biophysical features which have led to the suffering of the Maasai community. This community has experienced food insecurity which has proved difficult to resolve (Harriet *et al.*, 2013) since the impacts of climate shifts might go beyond their biophysical thresholds. Brown *et al.* (2007) and Dougill *et al.* (2010) are of the opinion that timely interventions are critical in realizing collective efforts that could curb the negative impacts of climate shifts considering the drops, downward spirals and dips in productivity.

Pastoral grazing space needs to be secured and the dryland ecosystem rejuvenated against the changing vegetation cover influenced by the rapid climate shifts that are threatening to render pastoralists destitute. However, restoring the pastoral Social-Ecological System could be complicated by multiple interactions among the various components in their ecosystem, ecology and socio-economic needs that occur in non-linear patterns (Walker *et al.*, 2004). The aforementioned problems arise due to complex relationships among components within the dryland landscape whose interactions are indirect (Walker *et al.*, 2004). These bottlenecks have also been reflected on the status of key nature-based resources such as the temporal and spatial scales that are currently declining, and as a result, lowering livestock productivity in the ASALs (Folke *et al.*, 2010). Kajiado County is not an exception; in the last decade, the Maasai community has experienced ecological degradation which is a threat to the sustenance of the pastoral livelihood system.

To sustain the pastoral livelihood system on natural pastures, one must factor in the role of the indigenous people (Schluter *et al.*, 2012). This is in agreement with Benjamin (1999) and Toulmin (1999) who noted that people inhabiting dryland ecosystems have over time circumvented the harsh climatic conditions through indigenous knowledge and have somehow managed to survive. Thus, nomadic pastoralism remains a vital coping strategy among the Maasai pastoralists as they have been able to access natural resources (Fitzgibbon, 2012) based on the seasonal pasture, water availability and the mastery of traditional migratory routes (GoK, 2012). To this end, anything that limits their mobility also reduces their survival as those who migrate experience fewer losses compared to resettled counterparts (Little *et al.*, 2001; Galvin, 2009). Therefore, attempts to

constrain mobility is counterproductive and it is marked with overgrazing, land degradation and poverty as individuals maximize utilization of the available resources (Schwartz *et al.*, 2005).

The levels of land degradation have been worsened by emerging trends such as alternative land use across space and time (Coughenour *et al.*, 1985). As much as the livestock sector is still viable in the dryland ecosystem, the implications of such shifts are not well understood. Thus, there is a need to have an in-depth understanding of the overall structure and forms of landscape in this context. It is also important for one to holistically look at the transformation in pastoral Social-Ecological System while interrogating its influence on the hurdles faced by the Maasai pastoralists. Additionally, there is a need for a thorough evaluation of the pastoral Social-Ecological System, their interrelations even as we align them to the traditions and socio-cultural setting. Beumer and Martens (2013) affirms that pastoralists have always deployed natural-based strategies in curbing the impacts of climate change and food insecurity. Oxfam (2008) opine that this encompasses the conservation of biodiversity through the active participation of the natives in managing their natural resources. According to Mutangah (2015), the presence of wild herbivores in the dryland ecosystem is due to the availability of palatable grass species associated with nomadic pastoralism. Moreover, the wild herbivores exhibit a great degree of co-existence or spatial overlaps with their livestock (Homewood and Rodgers, 1991).

Kajiado County has an assemblage of wildlife and biodiversity which supports eco-tourism (Behnke, 2000; Homewood *et al.*, 2009). This endowment has attracted tourism which has complemented the income of pastoralists albeit indirectly as tourism ventures extend their goodwill by the indigenous Maasai people for their conservation efforts. The vast fauna and flora has also contributed to the sustenance of the food web (Coughenour *et al.*, 1985; Ellis and Swift, 1988). Brundtland (1987) reported that traditions should be recognized and used for decision-making. According to Raburu *et al.* (2012) and Ezeanya-Esiobu (2017), indigenous knowledge contributes to the sustenance of wetland and it is important to safeguard it in the pastoral Social-Ecological System. To this end, indigenous knowledge is an integral component for adaptation strategy if one wants to attain resilience. The Maasai pastoralists have upheld traditions in an attempt to overcome seasonality while creating synergies that have helped in co-management of natural resources.

The Maasai community are highly dependent on ecosystem services for sustenance of pastoral livelihood system and that is why there is a linkage between their social-ecological setting and indigenous experiences (Adger, 2003). Similarly, Kratli *et al.* (2015) opine that the link between the native people and culture remains dynamic as a result of the rapidly changing climate and external influences which are threatening the sustainability of pastoralism and as such requires a timely intervention (Trujillo and Nakhooda, 2013). Therefore, this study aims to realise an in-depth understanding of such social-ecological dynamics as an insightful pathway in building the Maasai pastoralists' resilience.

## **2.5 Summary**

The literature review has demonstrated the complexity of pastoral Social-Ecological System to a range of responses namely: climate change, population increase, human resettlement, economic development, urbanization and change in land tenure system. Most studies have shown that shifts in the ecological systems must be matched by sustainable adaptation strategies to maintain resilience. In spite of this, little progress has been made so far in linking social, cultural, political and to ecological outcomes (Brunson, 2012). The Maasai pastoralists have continued to solely depend on livestock rearing for their survival which compromises on their resilience even though they have been able to sustain their ecology by upholding indigenous knowledge (OleSaitabau, 2014). Besides, less attention has been given to the Maasai pastoralists as they have been left out in planning and decision making on matters regarding their environment and economic livelihood (Mutu, 2017). Therefore, it is evident that the Maasai community are experiencing increased poverty levels, marginalisation and high dependency on food aid which were attributed to factors largely out of their control such as climate variability, altered land tenure policies or land use transformation making them less connected to their traditional social setting and heritage. It is inherent that policies should be enacted on the ground that the problem at hand is homogenous across different times and space (Hruska *et al.*, 2017). Measures such as livelihood improvement through livestock to replace the indigenous breeds might not be a feasible option for the Maasai pastoralists since it increases financial risks, alters grazing patterns, changes gender roles, increases labour intensity and decreases income for women (Wangui, 2008). Therefore, it is important to know the reasons that support grazing in a certain way or whether the Maasai pastoralists are still maintaining their unique connections with nature or not. To this end, it was

essential to carry out the study to effectively analyse the past and the present to ascertain the biophysical and social situation in the Maasai homeland. The findings would give a clear picture of the increased land-use transformation and encroachment which are rampant in the area due to the weak land tenure system.

## CHAPTER THREE

### STUDY AREA AND METHODS

#### 3.1 Introduction

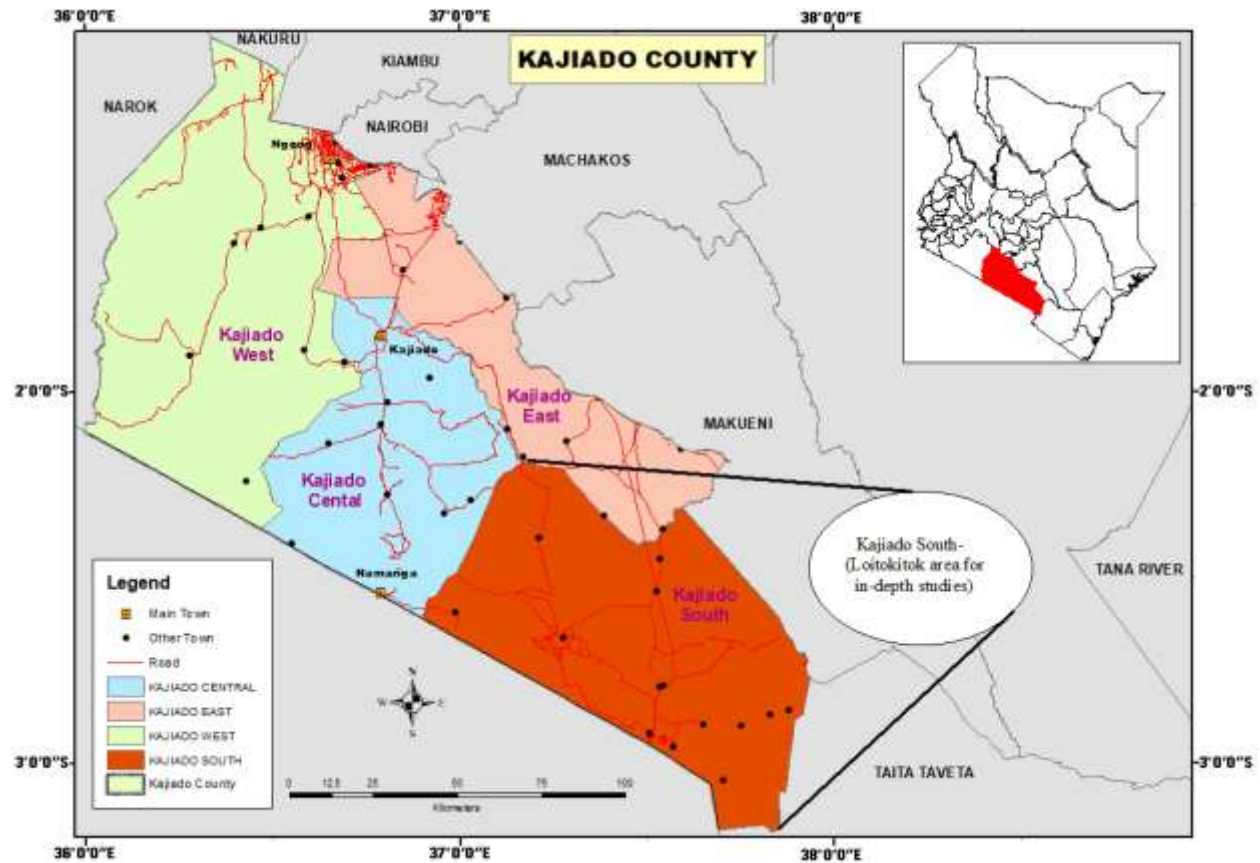
This chapter presents a detailed description of the study area which includes the location, study population, biophysical setting, climate, agro-climatic zones, water resources, biophysical vulnerability, socio-economic setting, political and administrative context, economic factors, social setting, health and socio-economic vulnerabilities. The chapter further describes the analytical methods used in the study and the conceptual framework. It also elaborates on the study design adopted, the samples size to represent the population, data sources and data collection procedures. Lastly, it provides an outline of tools used for primary and secondary data collection, processes conducted to assure the quality of the research process and their analyses covering objective 1, 2 and 3, respectively.

#### 3.2. The Study Area

Kajiado County is found in the southern region of Kenya and it is bordering five counties, namely; Nairobi, Nakuru, Machakos, Makueni and Taita Taveta counties as shown in Figure 3.1. The County also shares boundaries with Tanzania where it shares a segment of Mount Kilimanjaro in the Loitokitok region. In spite of its significance to the pastoral livelihood system, its nearness to Nairobi city is a recipe for bigger demand for land for investment in various sectors such as housing, agriculture, commerce and education. Therefore, the area faces imminent threats from human interference, population pressure compounded by climate change that informs the need for study in the area.

The County's average area is 21,900.9 km<sup>2</sup> and it is found between longitude 36° 5' and 37° 5' E and latitudes 1° 0' and 3° 0' S. Kajiado County lies at an altitude range of between 1580 and 2460 metres above sea level (GoK, 2016) and it is largely inhabited by the Maasai community (Mworio and Kinyamario, 2008). The dominant source of livelihood in terms of economic activity is pastoralism which is greatly dependent on natural pasture (Reynolds *et al.*, 2007).





**Figure 3.1:** Map of Kajiado County showing administrative boundaries and major towns

Source: Author

### 3.2.1 Population Trends

Table 3.1 shows that the County had a population of 1,117,840 in 2019. The County’s population density in 2019 stood at 51.11 inhabitants/km<sup>2</sup>, with a change of +4.8 per cent per year. The average household size is 3.5 which is almost the same as the national average household size which stood at 3.9 in 2019 distributed as 557,068 males and 560,704 females (KNBS, 2019). Furthermore, the population has grown considerably in the last 40 years from 149,005 in 1979 to 1,111,840 in 2019 as shown in Table 3.1.

**Table 3.1: Population trends**

Year	1979	1989	1999	2009	2019
Population	149,005	258,659	406,054	687,312	1,117,840

**Data source:** KNBS 2019

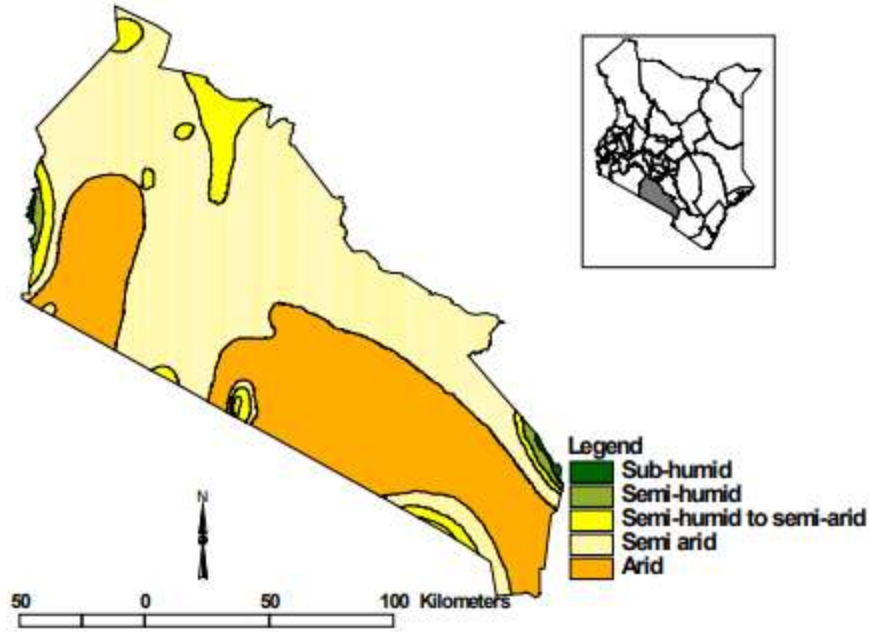
### ***3.2.2 Biophysical Setting***

#### ***3.2.2.1 Climate***

The area receives a bimodal precipitation regime with short rains in October to December (OND) and long rains in March to May (MAM). MAM is the expected main rainy season for more pasture regeneration while OND rains are for a short duration. These seasons are unevenly distributed and unreliable (Jaetzold *et. al.*, 2011). In addition, the annual average range of precipitation received is between 300 and 1300 mm with the lowlands receiving the lowest while elevated areas receive the highest precipitation. The temperature range varies between 20°C and 30°C throughout the year. However, temperature varies with altitude and season with Lake Magadi recording the highest temperature of 34°C while Loitokitok, which is around Mt. Kilimanjaro eastern slopes, recorded the lowest temperature of 10°C (MoALF, 2017).

#### ***3.2.2.2 Agro-Climatic Zones and Vegetation***

The agro-climatic zones classification is usually based on the spatial and precipitation patterns. Kajiado County agro-climatic zones consist of Sub-humid, derived grasslands and bushlands with an annual precipitation of 1,000-1,600 mm, Semi-humid-land of high agricultural value, low forest potential and it has an annual precipitation of 800-1,400 mm, Semi-humid with an annual precipitation of 600-700 mm to Semi-arid with an annual precipitation of 500-600 mm, Semi-arid with an annual precipitation of 300-550 mm. Lastly, Arid with an annual precipitation of 200-300 mm as shown in Figure 3.2 (NEMA, 2011).



**Figure 3.2:** Map of Kajiado County showing Agro-Climatic zones

**Source:** NEMA, 2011

### **3.2.2.3 Water Resources**

The water distribution network includes Tsavo River whose main tributaries are Nolturesh, Magoine and Rombo flowing from the Eastern slopes of Mt. Kilimanjaro and it provides water to Loitokitok and Uaso Nyiro River. There are also two streams in the Northern region of the Athi-Kapiti grasslands and Kibiko which provide water to the Northern part of Amboseli (Bekure *et al.*, 1991). Most rivers in the County depend on rains for recharge and they dry off during dry seasons (Erickson, 2010).

### **3.2.3 Socio-Economic Setting**

#### **3.2.3.1 Political and Administrative Context**

The County is divided into five sub-counties namely; Kajiado North, Kajiado Central, Kajiado South, Kajiado East and Kajiado West and it has a total of 17 administrative divisions. There are five constituencies in the County namely Kajiado North, Kajiado Central, Kajiado East, Kajiado South and Kajiado West and 25 County wards (GoK, 2016).

### 3.2.3.2 Economic Factors

Livestock accounts for most of the families' income and employs over 70 per cent of the households (Kirimi *et al.*, 2013). The other alternative sources of income include: soda ash in Magadi and marble in Kajiado Central (GoK, 2016). It is clear that Kajiado County is faring better than the nation's average as shown in Table 3.2, but this is skewed because some areas in the County are close to the Nairobi metropolitan that has a considerable big number of non-indigenous people who are engaged in Nairobi but inhabit the area and this applies to Tables 3.3 and 3.4. It is for that reason that this study focused on villages whose livelihood system is nomadic pastoralism. As such, the targeted locations exhibit high levels of poverty which was in contrast to these statistics but in agreement with the MoALF (2017) and GoK (2016) affirming the high intensities of poverty in the County at 53 per cent (population living under the poverty line).

**Table 3.2:** *Poverty levels of Kajiado County against national average*

Poverty levels	National %	Kajiado County %
1 Poverty incidences	45.2	38
2 Poverty severity index	4.9	2.3
3 Poverty gaps	12.2	7.8
4 Gini coefficient	0.45	0.40

**Source:** Social Economic Atlas of Kenya, 2016

### 3.2.3.3 Social Setting

The governance structure of the Maasai community encompasses: household (basic unit), the *boma* (several households in one compound), the neighbourhood (a cluster of *bomas*) and section (a group of neighbourhoods in the same area who may also jointly manage group ranches) and most of the decisions are made collectively. The grazing and water resources are controlled at the neighbourhood and section levels (Grandin, 1991) and the village elders play a critical role. This is in line with the Community Land Act No. 27 of 2016 and the Natural Resource Sharing Bill, 2014, which have sections that provide for pastoralist communities to contribute in the management and conservation of local resources. In addition, they have a section on the participatory process that includes political representation which if well implemented, could enhance management of natural systems within pastoral Social-Ecological System (Adger and

Barnet, 2007). Kajiado County has a fairly a larger younger population compared to the elderly population as shown in Table 3.3.

**Table 3.3:** *Household structure against national average*

	Household structure	National %	Kajiado County %
1	Population under the age of 18 years	50.1	48.0
2	Population over the age of 64 years	3.5	2.3
3	Orphans under the age of 15 years	1.2	0.6
4	Female-headed households	32.1	31.4

**Source:** Social Economic Atlas of Kenya, 2016

#### **3.2.3.4 Health**

The health facilities in the County are poorly equipped, understaffed and poorly distributed. This makes access to basic health care difficult as most of them rely on non-conventional methods such as traditional herbs which they use to treat common ailments for they are readily accessible.

Although the Maasai pastoralists in Kajiado County have various sources of water sources and conventional waste disposal methods, they are still exposed to water contamination and challenges in human waste disposal as shown in Table 3.4.

**Table 3.4:** *Access of water and sanitation against national averages*

	Water and sanitation	National %	Kajiado County %
1	H/H with access to safe water	56.1	67.2
2	H/H using piped water	30.0	36.8
3	H/H using protected springs/wells	14.3	4.7
4	H/H using borehole	11.0	25.3
5	H/H using stream of lake water	22.7	9.1%
6	H/H using ponds/dams	4.3	4.2
7	H/H using unprotected springs/wells	10.1	4.8
8	H/H using vendor water	6.5	14.5
9	H/H with access to improved sanitation	64.7	61.0
10	H/H with the main sewer/septic tank	11.1	11.3
11	H/H using bush	13.6	25.5

**Source:** Social Economic Atlas of Kenya, 2016

### 3.3 Methods

#### 3.3.1 *The Study Design*

The study used a mixed-method design which involved both qualitative and quantitative data. This design is robust and holistic hence it allowed an in-depth study. The primary datasets consisted of 195 questionnaires for the Household (HH) survey, 18 Key Informant Interviews (KIIs) and 8 Focus Group Discussions (FGDs). These tools were complemented with secondary datasets which consisted of remotely sensed rainfall data, station temperature data and Landsat datasets.

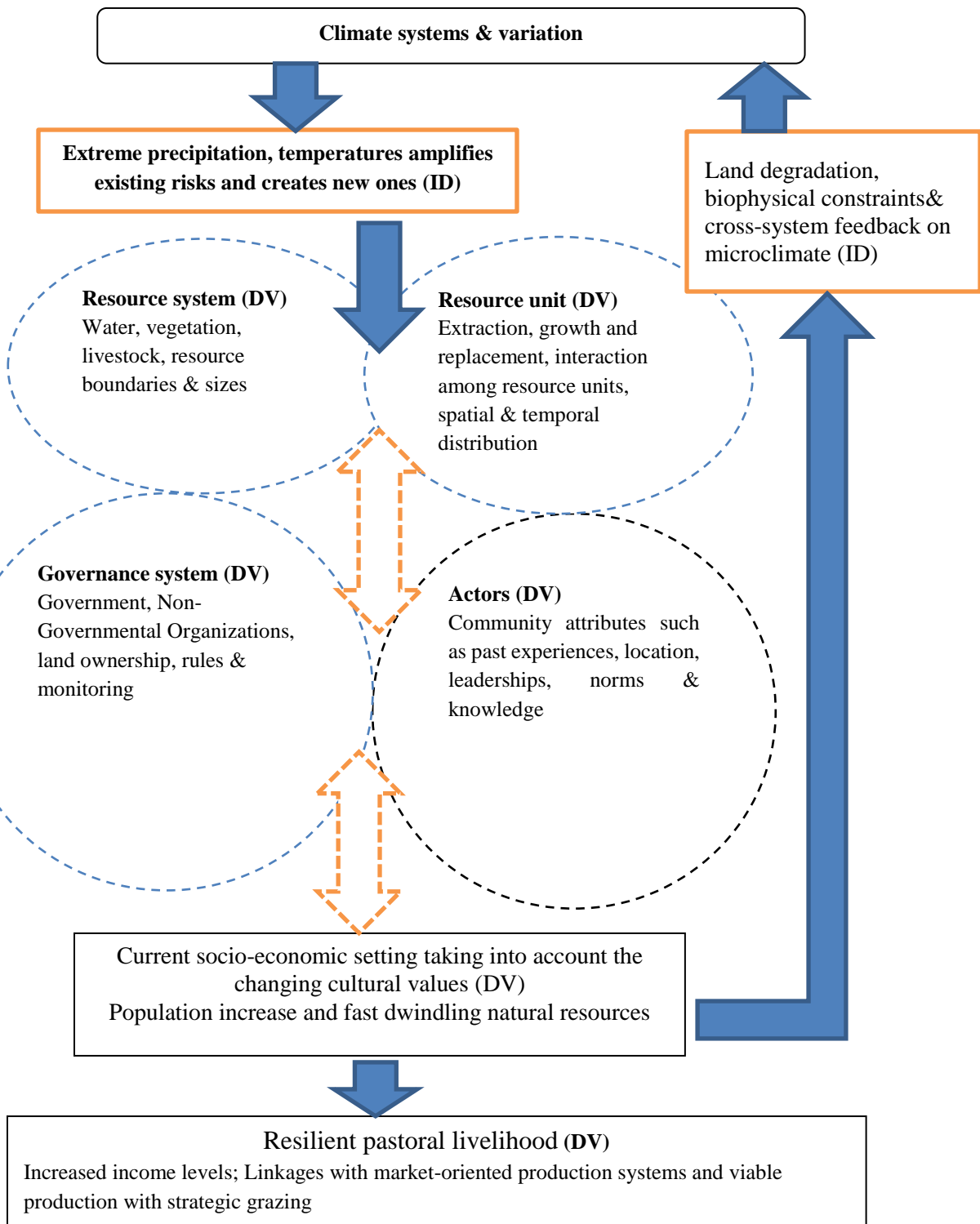
#### 3.3.2 *Conceptual Framework*

Social-Ecological System framework guides evaluation of resource systems, resource units, users and governance systems. This framework operates under a common pool of resource management situation where resource users extract natural resources from an ecosystem. The resource users are to provide for the conservation of the resource systems according to the rules and measures determined by the overarching governance structure (Ostrom 2007, 2009). Indeed, this is not a straight pathway but a rather complex process with interactive relationships that are interdependent which contributes to sustainable resource use and management as shown in Figure 3.3. Ostrom (2005) reported that this framework is supported by interconnected processes of extraction and maintenance. The study hypothesized that the Maasai traditional background provided prudent pathways and relations with greater potential for sustainability in an otherwise dire circumstance. The presumption is that traditional practices are for the mutual good and that they are logically anchored on conscious choices which translate to an endowment of fauna and flora in a region (Folke *et al.*, 2010). O'Brien *et al.* (2007) reported that the action of adherence to traditional practices has inculcated discipline which is fundamental for the sustenance of natural systems. Similarly, Holling (2002) and Robinson and Berkes (2011) and Gunderson supported traditional practices and recognized their fundamental roles in the quest of sustaining pastoral ecosystem. Adams *et al.* (1998) also reported that cultural institutions and heritage are integral components for improving resilience in the pastoral ecosystem. Similar sentiments were resonated by the IUCN<sup>20</sup> (2010) that advocates for an adaptation model that emphasises on the preservation of natural resources and biodiversity in voluntary stewardship as practised by the indigenous people.

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<sup>20</sup> International Union for the Conservation of Nature

The Maasai community have somehow managed to survive the adverse effects of shifting climatic patterns and land use transformation by utilising various interventions such as the extension of their migration routes beyond their territorial boundaries, promotion of non-pastoral livelihoods and by adopting livestock mix. In all these, survival mechanisms resonate within their cultural practices. O'Brien and Leichenko (2007) reported that geographical location, social context, governance structures, management dynamics, use of resources and economic relationships have had a profound impact on the pastoralists within and across the pastoral Social-Ecological System. Natural resources, which the Maasai pastoralists highly depend on, are dwindling to the point where sustainable pastoralism is threatened and this is attributed to environmental changes. It is imperative to note that this is a setback to the Maasai pastoralists who inhabit this dynamic ecosystem thus, it prompted the need for utilizing the Social-Ecological System framework which is rooted in cooperative actions theory to contribute sustainable resource use and management. Therefore, in-depth understanding of the Maasai pastoralists' way of life was necessary as a way of enhancing their capacities for them to keep up with climate change and land use transformation. This included their amalgamated governance and synergies which contributes to sustainable resource use and management. This is in line with Berkes and Folke (1998) who emphasised that indigenous people must be seen as part and not a part of nature when it comes to Social-Ecological System



**Key: DV-Dependant Variable; ID-Independent Variable**

**Figure 3.3: Conceptual framework**

**Source:** Adopted with modification from Ostrom, 2011



### ***3.3.3 Determining Historical Climate Trend (precipitation and temperature) and its Impacts on Pastoral Livelihoods.***

#### ***3.3.3.1 Desktop Studies and Secondary Data Collection***

The climate datasets were acquired from the Kenya Meteorological Department (KMD) and IGAD Climate Prediction and Application Centre (ICPAC). These datasets included temperature for the period 1970-2014 and precipitation for the period 1983-2014. The precipitation data - Climate Hazards Group Infra-Red Precipitation with Stations (CHIRPS) was extracted using GeoCLIM software<sup>21</sup>. They are satellite datasets from the raster file blended with ground data at a spatial grid resolution of 5km by 5km. CHIRPS datasets are globally accepted as an accurate data source (Shrestha *et al.*, 2017). The CHIRPS datasets are available from 1981 to date. Temperature datasets were retrieved from four Kenya Meteorological Department (KMD) stations in Kajiado County, namely: Ngong, Magadi, Isinya and Mashuuru. The 1970 was selected as the beginning point for the time series analysis grounded on the standard work with reference to the Fifth Assessment Report (IPCC, 2014) which reported that since the year 1970 the global average temperatures have been increasing at a rate of 1.7 °C and as such the year 1970 was the turning point for increasing global average temperatures. In both cases (station data and CHIRPS data), the study utilized monthly averages to generate time series for seasonal (MAM and OND), annual patterns of precipitation, maximum ( $T_{max}$ ) and minimum ( $T_{min}$ ) temperatures.

#### ***3.3.3.2 Field Studies and Primary Data Collection***

##### ***a) Research Assistants***

This study was participatory hence 8 local guides, conversant with each of the 8 villages in Kajiado County were identified by the backing of the area chief to administer project execution in each of the 8 villages represented in the research. Thereafter, a day training was held on 22<sup>th</sup> May, 2015, that involved 8 local guides together with the area chief and the village elders. As a prerequisite, the team was informed on the study objectives, the tools. Besides, guided on the kind of data to capture. The training also included explanation of difficult concepts.

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<sup>21</sup> [https://edcintl.cr.usgs.gov/downloads/sciweb1/shared/fews/geoclim/GeoCLIM1.2.0\\_Manual.pdf](https://edcintl.cr.usgs.gov/downloads/sciweb1/shared/fews/geoclim/GeoCLIM1.2.0_Manual.pdf)

### ***b) Reconnaissance Survey***

To familiarise with the study area, a reconnaissance survey was done between 23<sup>rd</sup> and 26<sup>th</sup> May, 2015, with the consent of the relevant authority (County Commissioner's office). Similarly, Monette *et al.* (2002) also reiterated the importance of carrying out a mock survey where a few respondents are involved before the real administration on a sampled population. This involved the researcher having familiarisation sessions with selected locals and experts who had stayed in the study area long enough to identify risks and opportunities associated with pastoral livelihood system. In addition, these sessions were necessary to facilitate cordial interaction with the people. This also created an opportunity for people to share their knowledge and experiences on climatic shift, risks and opportunities in that area. The feedback from these sessions enabled the researcher to reframe specific issues and align them in line with the study objectives. In other words, these sessions created a platform for the researcher and the local people to interact while at the same time winning their trust and support for the project.

### ***c) Field Surveys***

The official surveys started in October, 2015, and they were staggered between 26<sup>th</sup> May and 6<sup>th</sup> June, 2015 (pilot) and 9<sup>th</sup> May and 19<sup>th</sup> August, 2016 (actual administration). The surveys (HHs, FGDs and KIIs, described below) were administered to respondents from 8 villages in Loitokitok region in Kajiado South who were purposely selected (consent form is in Appendix 1). The details of the data collection tools administered were as follows: 195 Household questionnaire surveys (Appendix 2), 8 Focus Group Discussions (Appendix 3) and 18 Key Informant Interviews (Appendix 4).

#### ***3.3.3.2.1. Household Surveys***

The questionnaire for household survey entailed closed-ended Likert-scale questions that addressed people's perceptions. This is in line with Murray (2013) who asserted the usefulness of Likert-scale as a tool for assessing people's attitudes. The data acquired from the questionnaires for the household surveys were further triangulated by information obtained from 8 Focus Group Discussions (FGDs) (appendix 3) and 18 Key Informant Interviews (KIIs) (appendix 4) which are elaborately outlined in the next section. This is consistent with Denscombe (2010) opinion of procedural triangulation which reaffirmed the use of another data collection methods to generate

a provision for making the evaluation with findings from supplementary methods. In this essence, the qualitative data from the KIIs and FGDs were compared with the quantitative data from the questionnaires for the household surveys.

The household survey questionnaire was divided into four sections addressing issues corresponding to those of the structured questionnaires in the FGDs and KIIs, namely; section A (demographics profile), Section B (Climate trend and its impacts on pastoral livelihoods), Section C (pastoral Social-Ecological System and its influence on pastoralists livelihood) and Section D (Adaptation strategies to enhance the resilience of pastoral Socio-Ecological System)

The study employed the stratified simple random sampling approach. The participants, with similar characteristics, were grouped together. This was followed by administration of questionnaires randomly. Although, the questionnaires were dropped and picked to guarantee maximum response rate and reliability on the sampling frame of Loitokitok area of Kajiado County with a total population of 1,117,840 (KNBS, 2019). Since this research could not contact all of them, careful and systematic selection of representation targeting the Maasai pastoralists was carried out through homestead mapping directed by the chief and village elders. Similar strategy is also supported by (Mugo, 2002) who stated that a sample in a population is used to draw inference on the population. Thus, the sampling size was guided by the number of villages, the nature of villages, size of population, time and finances available. In conclusion, this research adopted the formula recommended for a social science study that has a huge population as Cochran equation (Godden, 2004),

$$n_0 = Z^2 p \frac{(1-p)}{e^2} \dots \dots \dots \text{Equation 1}$$

Where  $n_0$  = Sample size

$Z$  = zValue (1.96 for 95% confidence level)

$p$  =The estimated proportion of the population (assumed to be 50% or 0.5)

$e$  = Margin of error (assumed to be 0.07)

$$\text{Therefore } n_0 = \frac{1.96 \times 1.96 \times 0.5(1-0.5)}{0.0049}$$

$$n_0 = 196$$

$$\text{Adjusted Sample } (S) = \frac{n_0}{1 + \left(\frac{n_0 - 1}{P}\right)} \dots \text{Equation 2}$$

Where:  $P$  is the total population of Kajiado County = 1,117,840.

$$\text{Adjusted sample } (S) = \frac{196}{1 + \left(\frac{196 - 1}{1,117,840}\right)}$$

**Therefore adjusted samples for effective results is 195.**

According to the Cochran (1971), in a standard questionnaire the sample size to administer as shown in Equation 2. However, a total of two hundred questionnaires for the household survey were administered with each of the eight villages being allocated 25 questionnaires based on proportional share procedure, each of the 8 villages had an the same chance of being sampled in the entire outcome.

According to Boniface *et al.* (2014) response rate is stated as the portion of the eligible survey respondents who are contacted and questioned. In this context, two hundred questionnaires for household survey were distributed, 195 were completed and returned while five were returned incomplete leaving a total of 195 questionnaires for household survey whose feedback were found satisfactory. The feedback was equated to approximately a response rate of 97.5 per cent. This is consistent with Saunders *et al.* (2007) who stated that a response rate of 52 over 100 per cent is satisfactory for administrations.

### **3.3.3.2.2 Focus Group Discussions**

Focus Group Discussions (FGDs) were based on stratified random sampling approach with each of the 8 villages represented in the study provided with an opportunity for impartial distribution and balanced representation. These participants consisted of pastoralists who had settled in the Loitokitok of Kajiado County at least 10 years thus forming a common base of common experiences. Besides, it made it easy to make comparisons considering that they had a similar background. The researchers engaged with the community to a level where there was a mutually constructive exchange of in-depth information as shown in Plate 1.



**Plate 1:** *Focus Group Discussion session*

**Source:** Author's survey, 2016.

A total of eight gender-based Focus Group Discussions were administered across the 8 villages as shown in Table 3.5 with each Focus Group Discussions comprising 9 to 11 respondents. This is consistent with Dilshad and Latif (2013), recommendation that Focus Group Discussions (FGDs) participants should be in the range of six to twelve. These discussions were held between 9<sup>th</sup> May and 19<sup>th</sup> August, 2016, in churches and social halls where corresponding issues were addressed based on themes, namely: Section A (Climate trend and its impacts on pastoral livelihoods), Section B (pastoral Social-Ecological System and its influence on pastoralists livelihood) and Section C (Adaptation strategies to improve the resilience of pastoral Social-Ecological System).

The research assistants, who understand the Maasai language and were conversant with the area, engaged with the community to collect in-depth information on the Maasai pastoralists perceptions on sub-themes on pastoral social-ecological variables which were corresponding to those of the Likert-scale household questionnaire, namely: production levels, pasture, diseases, grazing cycles, cultural practices, markets and engagements which were well captured in section A of the FGDs questionnaire (Appendix 3). This is consistent with Krueger (2002), who stated the significance of

having themes in a organised questionnaire which guided the respondents as they narrated their experiences that were pertinent to the main issues of the study.

**Table 3.5:** *The FGDs villages*

	Villages	Livelihood systems	Settlement patterns	Field characteristics	No. of participants	
					Male	Female
1	Inkoi suk	Pastoral	Traditional	Communal	9	8
2	Mabateni	Pastoral	Traditional	Communal	11	9
3	Nasipa	Pastoral	Traditional	Communal	9	8
4	Olng'osua	Pastoral	Traditional	Communal	11	9
5	Isitet	Pastoral	Traditional	Communal	9	8
6	Inshura	Pastoral	Traditional	Communal	11	9
7	Kalesirua	Pastoral	Traditional	Communal	9	8
8	Namerok	Pastoral	Traditional	Communal	11	9

**Data source:** Author's survey, 2016

### 3.3.3.2.3 Key Informant Interviews

The sampling frame for Key Informant Interview was created from stakeholders from a consolidated list of forty institutions where eighteen institutions were selected from analysis and engaged in the interviews (Table 3.6). Ogallo (2014) stated that the interaction of the researchers with key informants is important for this kind of a research. His opinion is reinforced by Carter and Beaulieu (1992) who stated that Key Informant Interviews (KIIs) as a method of data gathering makes it likely for the researchers to obtain first-hand data from experts. In this context, the study focussed on gathering in-depth information about the area, pastoralism and its potential for increased resilience. Therefore, experts who are familiar with the area were affiliated to these institutions which were mostly Non-Governmental Organizations (NGO), self-help groups, government departments, and Faith-Based Organizations (FBO). This was in accordance with (Bogner *et al.*, 2009), who asserted that an expert is a resource person who has a special knowledge

in a specific field thus their contribution is important in data collection exercise. KIIs interview sessions were conducted face-to-face between 12<sup>th</sup> and 14<sup>th</sup> August, 2016 and the discussions were held in their respective offices guided by the themes, namely; production trends, migration patterns, the impacts of climate shifts on pastoral livelihood as captured in section A of the structured questionnaires (Appendix 4). This approach borrowed heavily from Morgan (2006) affirmation that shared experiences from various points of view enables amalgamation of a wider world view and makes comparison probable particularly when it comes to the main issues.

**Table 3.6:** *The KIIs list of affiliated institutions*

S/N	Organisation	Roles	Dates
1.	Dupoto Emaa	Training, coordinating community and value chain development group	12 <sup>th</sup> August, 2016
2.	NEMA	Regulate the usage of natural resources by conducting EIA	12 <sup>th</sup> August, 2016
3.	KWS	Protection of wildlife	12 <sup>th</sup> August, 2016
4.	Kenya Red Cross	Food aid as a drought emergency intervention	12 <sup>th</sup> August, 2016
5.	Kenya Forest Service	Safeguarding natural forests and wetland	12 <sup>th</sup> August, 2016
6.	Representatives of conservancies	Protection of biodiversity	12 <sup>th</sup> August, 2016
7.	NDMA	Food aid as an emergency drought response, building enhancement programmes of pastoral field schools, forage development and conservation and	13 <sup>th</sup> August, 2016
8.	NARASU	Livestock marketing	13 <sup>th</sup> August, 2016
9.	Catholic Diocese	Livestock breed enhancement programmes of livestock producers and pasture development.	13 <sup>th</sup> August, 2016
10.	Olmaa Pastoralist Development Organization	Livestock breed improvement programmes, capacity and skills enhancement of livestock producers	13 <sup>th</sup> August, 2016
11.	Amboseli Ecosystem Trust	Capacity enhancement on pasture development and fodder establishment	13 <sup>th</sup> August, 2016

12.	Dupo Ee Maa	Restocking, pasture and fodder establishment	13 <sup>th</sup> August, 2016
13.	Reto Women	Building capacity of communities on water harvesting skills	14 <sup>th</sup> August, 2016
14.	Neighbours Initiative Agency	Pasture and fodder establishment, poultry production and beekeeping	14 <sup>th</sup> August, 2016
15.	County Land, Physical Planning Unit and Urban Management	Surveying unit for the County and demarcation of all boundaries  Administration and management of all land records, advising and dealing with all issues related to land subdivision.	14 <sup>th</sup> August, 2016
16.	Mainyoito Pastoralist Integrated Development Organization	Building capacity on programmes related to animal husbandry, abattoirs, yards, livestock sale and livestock disease preventive and control measures	14 <sup>th</sup> August, 2016
17.	Southern Ranch Land Organization	Custodian of community ranches	14 <sup>th</sup> August, 2016
18	County Commissioner	Handling of security and early warning issues within the County and food aid distribution. Organise all the planning units within the County for the purpose of administration.	14 <sup>th</sup> August, 2016

**Data source:** Author's survey, 2016

### ***3.3.3.3 Data Analysis***

The analyses of data commenced once editing and coding had been carried out. Thereafter classification and tabulation of the raw data were in captured in excel spreadsheet in promptness for extraction. Further analysis were carried out on STATA statistical package where descriptive and inferential statistics were generated.

#### ***3.3.3.3.1 Time Series Analyses***

The climate variables were analysed and plotted using time series to establish the climate trends. These included CHIRPS (1983-2014) and KMD (1970-2014) data. The monthly precipitation and temperature were captured in the Excel spreadsheet in promptness for extraction. Additional



analysis were carried out in the STATA statistical package. These produced results in the form of graphs which were all plotted and fitted with the lines of best fit generating the  $Y = \beta_0 + \beta_1 X_1 + \varepsilon$  to show how the trends were over time. The null hypothesis, in this instance, was that the gradient coefficient  $\beta_1 = 0$  whereby  $\beta_1$  is verified to determine if it is significantly different from zero. So, statistical significance was considered at  $\alpha = 0.05$ . In the linear equation of Y on X, Y represents either precipitation (wet seasons MAM and OND) or temperature ( $T_{\max}$  and  $T_{\min}$ ) and X is time expressed in months, seasons (MAM and OND) or years.

#### ***3.3.3.3.2 T-Test***

Hypothesis testing involved splitting climate variables data into two parts and the study period was split into two halves in terms of early years (from 1983 to 1998 period) and later years (from 1999 to 2014 period). Before conducting t-test, the data were entered into an Excel spreadsheet where descriptive statistics data for climate variables were summarised. The statistics generated included: mean, median, minimum and maximum. Further, the computed means for precipitation and temperature for the early and later years were compared using the t-test and coefficient of variation. Statistical significance was considered at  $\alpha = 0.05$ .

#### ***3.3.3.3.3 Frequencies, Percentages and Scores for Likert-scale***

The demographic characteristics (Section A) of the respondents were analysed using frequencies and percentages in terms of education, age and gender ratios. Further, analyses were done on sections B, C and D of the Likert-scale household surveys questionnaire. This involved a range of responses which were rated on a scale of 2 to -2 (where the numbers were represented as follows: 2 - very high; 1 - high; 0 - neutral; -1 - low and -2 - never with each questions coded using SPSS and the descriptive statistic calculated into frequencies and mean scores which indicated the people's attitude based on the central tendencies of all response given on Social-Ecological System. In this context, eight attributes namely: herds' body conformation, herd sizes, pasture deficit months, management cost, grazing cycles, cultural practices, markets and engagements were evaluated (section B, Appendix 2). The impacts of shifting climatic patterns on pastoral livelihood was measured on an attitudinal gauge (Hsieh and Sharron, 2005). According to Bonne (2012), the survey on perception or attitude is affirmed when the mean score is greater than zero (positive) it implies affirmation but when it is less than zero (negative) it implies disapproval. For

instance, 0.78 would indicate affirmation to the Likert item in question while – 0.35 would indicate disapproval based on the concept being assessed by the survey items.

#### ***3.3.3.3.4. Thematic Analysis***

FGDs and KIIs generated people’s experiences which were qualitative data in the form of field notes. These datasets were transcribed and verified based on the context. Cleaning and coding was done before data entry where the various emerging themes and sub-themes based on Social-Ecological System were generated (Ostrom, 2009) and analysed using NVivo version 10 which compared corresponding variables followed by a score of the groups that had comparable themes and sub-themes. This enabled the researcher to identify similar views based on the themes and sub-themes which were validated by the emerging patterns.

### ***3.3.4 Evaluating Pastoral Social-Ecological System and its Influence on Pastoral Livelihood System.***

#### ***3.3.4.1 Desktop Studies***

Data on the status of land cover were sourced from the processed Landsat 8, 5 and 4 satellite imagery available as open source from [www.glovis.usgs](http://www.glovis.usgs) supported by “National Aeronautics and Space Administration” (NASA).

##### ***3.3.4.1.1. Land Use and Land Cover changes to evaluate the status of biophysical attributes***

Remote sensing technology was applied where Landsat dataset 8, 5 and 4 were used to develop land cover maps for the years 1987, 2000 and 2015. These quantitative satellite datasets were sourced from [www.glovis.usgs.org](http://www.glovis.usgs.org) and are available as open data portal. The “Land Use and Land Cover” mapping sought to determine the changes that had taken place over time.

Remote sensing according to Shuckman *et al.* (1987), is the science of deriving evidence about the Earth features from images picked up at a distance while relying upon measurements of electromagnetic energy emitted or reflected from the feature of interest. Remote sensing and GIS technique are essential for mapping as it enables fieldwork covering larger areas to be accomplished at a lesser cost and more quickly (Barret and Curtis, 1982). Thereafter, the GIS

database generated is then run on ArcGIS software to detect noticeable change. The GIS is a software used widely and its applications are constantly expanding over time.

The mapping development process was as follows:

#### **(a) Acquisition of Satellite Images**

Remote sensing and GIS technique were used to analyse historical Land Use and Land Cover which included vegetated areas and artificial surfaces (Barret and Curtis, 1982). These consisted of Landsat 8, 5 and 4. The study extracted 1987, 2000 and 2015 epochs which had a spatial resolution of 30m obtained from [www.glovis.usgs.org](http://www.glovis.usgs.org) while focussing on the dry season imagery (cloud-free) i.e. January-March and July-September (Tiwari and Saxena, 2011) as the heavy clouds would lead to poor images.

#### **(b) Processing of Satellite Images**

The raster form of datasets for 1987, 2000 and 2015 epochs underwent pixel-based screen supervised classification (Barret and Curtis, 1982). The classified data generated were edited using interactive and batch mode. This process encompassed layer-stacking, sub setting and mosaicking using ArcGIS and impact tool (JRC<sup>22</sup>) (Barret and Curtis, 1982). The generated pre-processed database from which analysis was done utilised ancillary data in which case ILRI polygons which readily available shape files and were used to derive control points such as roads, rivers and administration boundaries that were used to geo-reference the coordinates in the base maps.

#### **(c) Interpretation of Satellite Imagery**

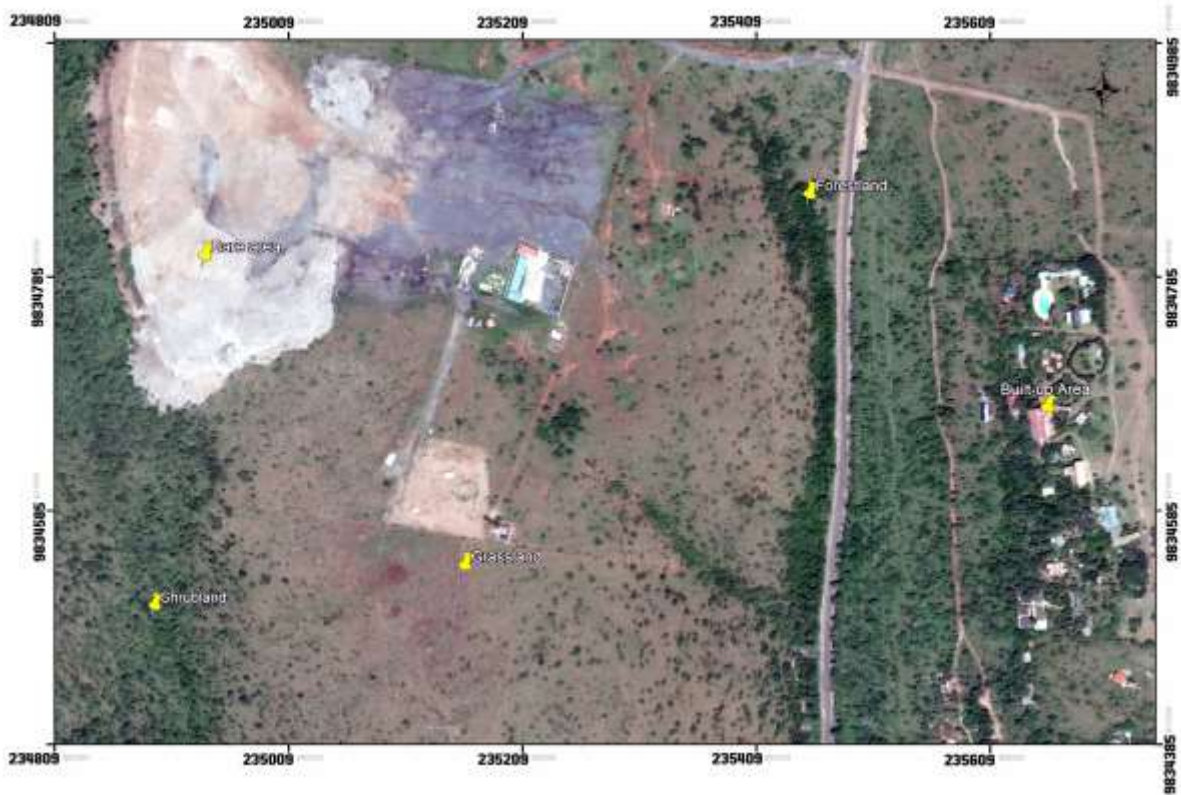
Image classification process involved identifying features on LULC maps through supervised classification maximum likelihood classifier (Enderle and Weihjr, 2005) methodology in ENVI software platform from which each of epoch image with nine land use classes acknowledged based on the “Food and Agriculture Organisation (FAO) Land Cover Classification System (LCCS)” was adopted. The major land cover types were: built-up area, bare area, cropland, grassland, forestland, riverine, shrubland, wetland and waterbody.

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<sup>22</sup>Joint Research Centre is a research-based policy support organisation and an integral part of the European Commission

#### (d) Validation and Quality Checking

The validation of the output of the land cover was done before the final interpretations. The first draft of images generated were further analysed. It involved field checks which further confirmed the identified land cover categories latent to the Landsat imagery. This was carried out according to Lillesand *et al.* (1994) where validation targeted specific parts of interest which were cross-checked using high-resolution imagery from Google Earth to verify accuracy of the maps and assist in further identification of uncertain area marked during interpretation as shown in Plate 2.



**Plate 2:** Google Earth image showing biophysical features on a section of Kajiado County

**Source:** Extracted by the Author, 2016

### ***3.3.4.2 Field Studies and Primary Data Collection***

#### ***3.3.4.2.1. Household Surveys***

An elaborate description of how information was collected from the Likert-scale household surveys are captured in section 3.3.3.2.1. Here, the focus was mainly on the shift in Social-Ecological System influence on pastoral livelihood, namely; demarcation, receding water, enclosure resettlement and invasive species whose details are shown in Section B, Appendix 2.

#### ***3.3.4.2.2. Focus Group Discussions***

The detailed information describing how FGDs were applied to collect useful information are in section 3.3.3.3.2. Here, the key aspects corresponding to the Likert-type questionnaire were administered in the form of structured questions to generate in-depth information from the Maasai community as shown in Section B, Appendix 3.

#### ***3.3.4.2.3. Key Informant Interviews***

The detailed information describing how KIIs were applied to collect useful information are in section 3.3.3.2.3. Here, key aspects corresponding to the Likert-type were administered in the form of structured questions to generate in-depth information from the experts as shown in Section B, Appendix 4.

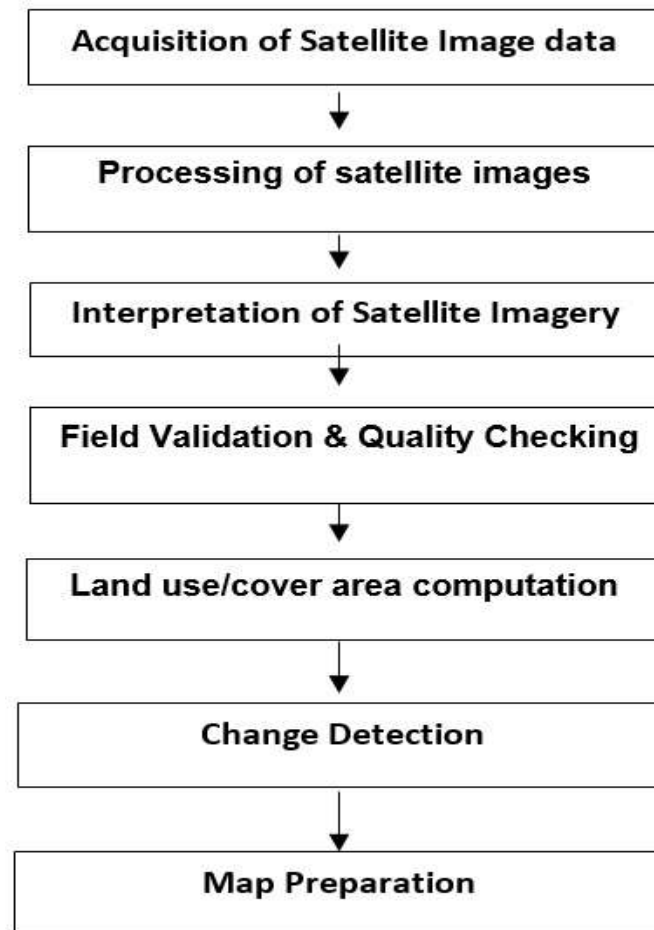
### ***3.3.4.3 Data Analysis***

The analyses of data commenced once editing and coding has been done. Thereafter, classification and tabulation of the raw data is completed ready for extraction into the ENVI software. Further analysis was done using ArcGIS on satellite datasets to establish land cover changes in the form of land cover maps by cross-referencing the different years.

#### ***3.3.4.3.1 Land Use and Land Cover Area Computation***

The resulting maps which included 1987, 2000 and 2015 were imported and overlaid into ArcGIS software for analysis while factoring in the main land cover classes. The maps were compared and manipulated through overlays to extract the total areas under the nine land cover types and quantify the LULC changes in hectares.

The entire process followed is shown in Figure 3.4.



**Figure 3.4:** *Flow chart on LULC mapping development process*

**Source:** Author

Once the satellite data for each year had been obtained, GIS and Remote sensing methods were applied to develop land cover maps for the years 1987, 2000 and 2015. These maps were subjected to validation using sample points collected from high-resolution images from Google Earth as ground truth data. Interpretations of changes in Land Use and Land Cover in the form of statistics were derived from the land cover maps by cross-referencing the different years of the land covers, namely: between 1987 and 2000, 2000 and 2015 and 1987 and 2015.

Further, the rate of land use change per year was computed using the formula (Chebet, 2013):

$$R = \frac{Y-X}{T} \dots\dots\dots \text{Equation 3}$$

Where:

R is the rate of change

Y is the area in hectares of the study area in the final year

X is the area in hectares of the study area in the initial year

T is the difference in years.

The percentage rate of changes for the various Land Use and Land Covers were calculated by dividing the rate of change land use change per year by the original areas respectively for change detections.

#### ***3.3.4.3.2. Frequencies and Scores for Summative Likert- Scale***

Typically, these responses measured how the shifting Social-Ecological System influences pastoralists' livelihood. In this context, five attributes namely: demarcations, receding water levels, enclosure, resettlement and invasive species from which the respondents were probed to indicate their answers based on a five-point Likert-scale where, +2 = very great; +1 = great; 0 = neutral; -1 = lesser extent; -2 = none of all as shown in Section B, Appendix 2. Thus, each of the five items had its frequency and mean score (Hsieh and Sharron, 2005). According to Bonne (2012), the survey scale on perception or attitude is affirmed when the mean score is greater than zero (positive) and disapproved when it is less than zero (negative) based on the concept being assessed by the survey items. Details describing how frequencies and scores for household surveys were carried out are in section 3.3.3.4.3.

#### ***3.3.4.3.3 Thematic Analysis***

Themes were based on the highlights of social-ecological variables (Ostrom, 2009). The themes and the sub-themes enabled the researcher to identify similar views as the participants narrated their experiences which were validated by the emerging patterns. Details describing how thematic analysis were carried out are in section 3.3.3.4.4.

### ***3.3.5 Determining Adaptation Strategies to Enhance the Resilience of the Pastoral Social-Ecological System to Climate Change and Land Use Transformation.***

#### ***3.3.5.1 Field Studies and Primary Data Collection***

##### ***3.3.5.1.1 Household Surveys***

As stated earlier in Objective 2, an elaborate description of how information was collected from the Likert-type household surveys is captured in section 3.3.3.2.1. Here, the focus was on how the community has tried to cope with the shift in the Socio-Ecological System in relation to climate change and land use transformation. In this context, the study sought to understand Social-Ecological System indicators and the expected direction concerning climate change and how it influences adaptation strategies among the Maasai pastoralists. In this regard, there is no general approach for applying Social-Ecological System framework (Hinkel *et al.*, 2015) therefore, variables can be adjusted and measured, as need be, in a different context (Ostrom, 2007, 2009). Here, the Likert-type highlighted the various adaptation options, namely: food aid, remittance, employment, handicrafts, beekeeping, insurance, partnerships capacity support, peace initiatives, shoats and camels (livestock mix or diversification) and structured markets where they could sell their merchandises as shown in Section B, Appendix 2.

##### ***3.3.5.1.2 Participatory Learning and Action Approach***

Two participatory stakeholders' forums held between 6<sup>th</sup> August and 8<sup>th</sup> September, 2016 in the social hall (Plate 3) to take care of the participants' concerns in terms of risks and opportunities posed by anthropogenic activities and changing climate. Here, the Maasai pastoralists were asked to discuss among themselves and come up with a list of risks and opportunities. Lastly, each group of participants presented their views to the plenary session and as they did so, the researcher interjected at regular basis to probe further where necessary to maintain the focus according to the study's objective. This participatory exercise generated common features which were nested and their hierarchy illustrated through simple ranking. Catley *et al.* (2012), asserted that a structured ranking method can be used to prioritize and list options. However, where there is a tie, then further consideration was given to break the tie hence giving one a higher ranking.





**Plate 3:** *Participants using participatory learning and action approach in one of the community engagement sessions while ranking various adaptation strategies.*

**Source:** Author's survey, 2016.

### ***3.3.5.2 Data Analysis***

The data analysis was based on the decision support tool generated from participatory Learning and Action approach. As part of the participatory stakeholders' forums, the Maasai pastoralists were given an opportunity to discuss and come up with a list of risks and opportunities. Thereafter, they ordered these variables through simple ranking while highlighting the risks and opportunities based on their preference. Additionally, frequency, percentages and scores were used to analyse the Likert-type questions. Lastly, to bring relational analysis at segregated levels of significance, Chi-Square statistics was employed. In this context, Chi-Square was used to check for independence on whether there is a relationship among the adoption of coping strategies concerning climate change and land use transformation.

#### ***3.3.5.1.3 Frequencies, Percentages and Scores for Likert- Scale***

These analyses revealed representation of the community's attitude towards proposed adaptation intervention on an ordinal scale measured in 5-point scale, where, +2 = very great, +1 = great, 0 = neutral, -1= lesser extent, -2 = none of all. Here, the study sought to explore the degree of adoption of various interventions. The outlined measures were: food aid, remittances, employment,

handcraft, beekeeping, insurance, partnerships, peace initiatives, capacity support, livestock mix and structured markets. These measures were put in place to enhance the Maasai pastoralists coping ability as shown in Section D, Appendix 2. Results are shown in Table 6.1.

#### ***3.3.5.1.4 Thematic Analysis***

Thematic analysis is a good research approach, especially where the researcher is attempting to find out specific information on local participants' knowledge, view, opinions or preferences. Therefore, from a set of qualitative data, the researcher was able to reflect why certain trends exist based on the representative data on risks and opportunities generated during participatory forums. These qualitative data were systematically reviewed and the gaps were identified to inform large scale generalisation in the implementation of adaptation strategies. Thereafter, the contents were consolidated through thematic analysis which identified and interpreted the risks and opportunities posed by the shift in the Social-Ecological System concerning climate change and land use transformation. Here, themes, sub-themes or patterns were recognized and analyzed through categorization to present the locals' in-depth knowledge with a focus on interdependent linkages between Social-Ecological System and climate change and land use transformation. In this connection, the study sought to find the extent to which a set of selected coping mechanisms have improved the household resilience capacity since the Maasai pastoralists are highly dependent on natural systems and variation of natural resources are of great concern.

#### ***3.3.5.1.5 Chi-Square Test for Independence***

Chi-square test ( $\chi^2$ ) used to analyse the 5-point scale Likert form of questions. The test measured how the predictable variables compared to the real observed data to test whether the frequencies in each cluster of respondents was considerably different from what would be predictable if the attributes studied were independent from each other. The Chi-square test analysed the variables categorically to scrutinise the null hypothesis that the attributes represented by the columns are independent of the variables represented by the rows. This should have also apply vice versa, alongside a contrary alternative hypothesis.

The test statistic,  $\chi^2$  computed, was based on the frequencies and is computed as follows:

$$\chi^2_{computed} = \sum_{i=0}^n \frac{(\theta_i - \epsilon_i)^2}{\epsilon_i} \dots \dots \dots \text{Equation 4}$$

Where;

$\theta \equiv$  The observed frequency

$\epsilon \equiv$  The expected frequency

$n \equiv$  The number of observations ( $n = r \times c$ )

$r \equiv$  Number of rows

$c \equiv$  Number of columns

The critical statistic for the test,  $\chi^2_{critical}$ , is usually obtained from the Chi-Square distribution tables at the specified significance level and the existing degrees of freedom i.e.

$$\chi^2_{critical} = \chi^2_{\alpha, v} \dots \dots \dots \text{Equation 5}$$

Where;

$\alpha \equiv$  Significance level

$v \equiv$  Degrees of freedom, computed as;

$$v = (r - 1) \times (c - 1)$$

The decision rule of the test requires that the null hypothesis is rejected if  $\chi^2_{computed} \geq \chi^2_{critical}$

## CHAPTER FOUR

### PASTORAL COMMUNITY DEMOGRAPHICS, HISTORICAL CLIMATE TRENDS AND ITS IMPACTS ON PASTORAL LIVELIHOODS

#### 4.1 Introduction

This chapter presents results on demographic characteristics, namely; education levels, age groups and genders which were necessary for the understanding of the Maasai pastoralists' ways of life. The detailed results on precipitation trends for the period 1983 to 2014 which focuses on the annual, MAM and OND seasons are also included. Additionally, the results on temperatures which cover the years 1970 to 2014 for both the maximum ( $T_{max}$ ) and minimum ( $T_{min}$ ). Lastly, the results from the household surveys and triangulate them with the data and information from the FGD and KII on impacts of climatic shift on their livelihood system.

#### 4.2 Demographic Characterisation of the Survey Respondents

These results revealed the representation of each quota in the sample ranging from education level as shown in Table 4.1, age bracket as shown in Table 4.2 and gender as shown in Table 4.3.

**Table 4.1:** *Households survey respondents disaggregated by education levels*

S/N	Villages	No formal education	Primary education	Secondary education	Tertiary education	Number of respondents
1	Inkoisuk	10	11	3	1	25
2	Mabateni	10	12	2	1	25
3	Nasipa	7	13	4	1	25
4	Olng'osua	10	12	2	1	25
5	Isitet	9	13	2	1	25
6	Inshura	8	12	5	1	25
7	Kalesirua	7	13	3	2	25
8	Namerok	7	13	3	2	25

**Data source:** Author's survey, 2016

#### 4.2.1 Categorisation by Level of Education

The results in Table 4.4 show the distribution of the respondents in terms of education levels. From the findings, 34.88 per cent (68) had no formal education, 48.13 per cent (94) had primary education, 12.5 per cent (24) had secondary education and 4.49 per cent (9) had tertiary education. This is an indication that the majority of the Maasai pastoralists in Kajiado County can read, write and even understand concepts if given the opportunity though it was also established that some of them are not educated. Their access to education is facing some challenges because the mobile schools that offer the best mode of content delivery have not been adequately distributed in the area. Lutz *et al.* (2014) opine that formal education is critical to help address climate change-related challenges given that it can enhance the community's capacity in decision making. Besides, those with higher education levels have an advantage in being able to seek information which is an important attribute to take into consideration as it influences responses to adaptation choices and level of adaptation uptake (Maddison, 2006; Hassan and Nhemachena, 2008).

**Table 4.2:** Households survey respondents disaggregated by age

S/N	Villages	Youth 24-29 years	Senior youth 30-35 years	Elders 36-78 year	Number of respondents
1	Inkoisuk	6	6	13	25
2	Mabatani	5	5	15	25
3	Nasipa	6	5	14	25
4	Olng'osua	5	6	14	25
5	Isitet	4	6	15	25
6	Inshura	6	5	14	25
7	Kalesirua	6	6	13	25
8	Namerok	5	7	13	25

**Data source:** Author's survey, 2016

#### 4.2.2 Categorisation by Age

The results in Table 4.4 shows the age distribution. From the findings the youths (age group 24 to 29) were 21 per cent (41 respondents), senior youths (age group 30 to 35) were 23 per cent (45 respondents) and the elders (age group 36-78) were 56 per cent (109 respondents). The study established that the majority of the respondents (56 per cent) were elders (age group 36-78). This was the group that delivered most of the in-depth information since they had been inhabiting the area for a long time and were more mature to discern the issues to do with cultural practices dating many years back. However, the other age groups were also important since they were familiar with the emerging technologies which could be integrated into pastoral dynamics for it to be more effective. Besides, the incorporation of the various age groups made the study more inclusive.

**Table 4.3:** *Households survey respondents disaggregated by gender*

S/N	Villages	Females	Males	Number of respondents
1	Inkoisuk	12	13	25
2	Mabatani	12	13	25
3	Nasipa	12	13	25
4	Olng'osua	11	14	25
5	Isitet	12	13	25
6	Inshura	12	13	25
7	Kalesirua	12	13	25
8	Namerok	12	13	25

**Data source:** Author's survey, 2016

#### 4.2.3 Categorisation by Gender

The results in terms of gender and the respondent distribution was as follows; 52.5 per cent (102 respondents) were male and 47.5 per cent (93 respondents) were female as shown in Table 4.4. This is an indication that the desired 1:1 ratio was almost attained. The men were slightly higher

but this was a satisfactory representative sample as per Kothari (2004), considering that this ratio was within the stipulated range. The attainment of gender balance is an important attribute since it enriches the study as well as ensures that the gender roles are incorporated. Therefore, gender could not have been overlooked as it could have affected the proactive engagement of women who make up a significant quota of the population in this community. In addition, the widows and female-headed households could have been left out considering the patriarchal nature of the Maasai community (Western and Nightingale, 2003).

**Table 4.4:** *Demographic characteristics of respondents in Kajiado County*

S/N	Variable	Attributes	Respondents (N=195)	Percentage (%)
1	Education level	No formal	68	34.88
		Primary	94	48.13
		Secondary	24	12.5
		Tertiary	9	4.49
2	Age (Years)	Youths (24 to 29)	41	21
		Senior youths (30 to 35)	45	23
		Elderly (36 to 78)	109	56
3	Gender ratio	Male	102	52.5
		Female	93	47.5

**Data source:** Author's survey, 2016

### 4.3 Precipitation Trends

Table 4.5 shows a summary for precipitation parameters for Kajiado County, from 1983 to 2014 period (30 years). From the findings, the average seasonal precipitation was quite low with the MAM season mean being 91.9 mm and OND season mean being 69.9 mm. Further analysis involved splitting the precipitation datasets into two equal parts. Here, the early years (from 1983 to 1998 period) and the later years (from 1999 to 2014 period) means were calculated and compared to test whether there was evidence of significant change ( $p < 0.05$ ). The results show that there was a decrease in the mean and (SD<sup>23</sup>) of rainfall in the MAM season in the 1983 to 1998 period [94.2 (27.7)] (CV = 29.4%) compared to the 1999 to 2013 period [89.6 (25.4)] (CV<sup>24</sup> = 28.3%) but the decrease was not statistically significant ( $p < 0.05$ ). In addition, there was a slight increase in the mean and SD of rainfall in the OND season from the 1983 to 1998 period [68.6 (27.5)] (CV = 40.1%) compared to the 1999 to 2014 period [71.1 (27.1)] (CV = 38.1%) but the increase was statistically insignificant ( $p > 0.05$ ).

**Table 4.5:** *Descriptive statistics for precipitation*

Parameters	Rainfall - MAM			Rainfall - OND		
	Long-term	1983-1998	1999-2014	Long-term	1983-1998	1999-2014
Mean	91.9	94.2	89.6	69.9	68.6	71.1
Variance	690.1	770.0	647.7	720.0	755.0	733.0
SD	26.3	27.7	25.4	26.8	27.5	27.1
Min	42.2	42.2	50.5	29.9	29.9	31.3
Q1	79.1	81.8	62.5	46.7	44.6	46.7
Median	95.0	99.7	94.7	69.6	67.8	76.4
Q3	108.3	113.9	108.3	87.0	82.5	88.1
Max	146.0	146.0	127.5	133.2	133.2	133.2
Difference			-4.7			2.5
t-statistic			-0.5			0.3
p-value			0.317			0.598

**Data source:** “Climate Hazards Group Infra-Red Precipitation with Stations” (CHIRPS)

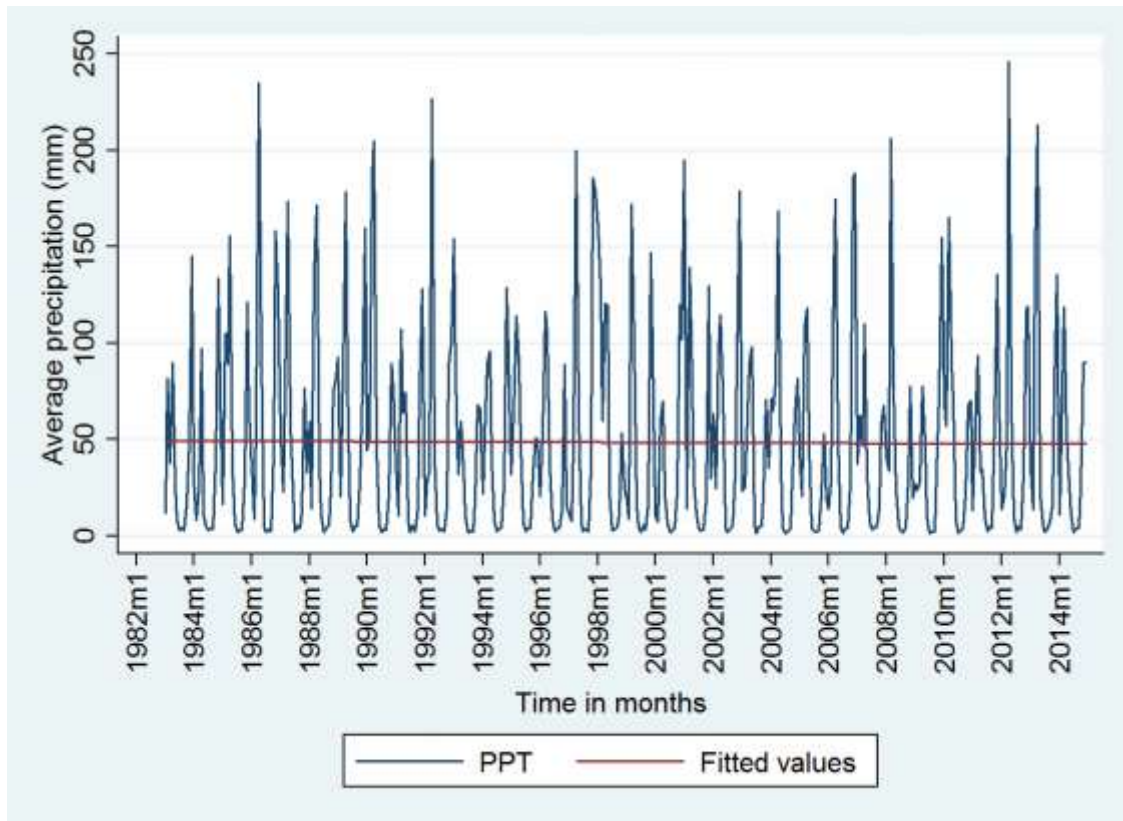
<sup>23</sup> Standard Deviation

<sup>24</sup> Coefficient of Variation



### 4.3.1 Average Annual Precipitation

Figure 4.1 shows the results of a long-term linear relationship between the years and average annual precipitation between 1983 to 2014 period in Kajiado County. The time series analysis has a negative slope which implies that there was a decline in precipitation i.e.  $y = 50.6108 - 0.0044x$ . However, this decline was statistically insignificant ( $p > 0.05$ ).



**Figure 4.1:** Average annual precipitation trends for Kajiado County (1983-2014). NB: M1 refers to the first month of every year across the 1984-2014 period as shown; however, all the months were used in the trend at  $p < 0.05$  for precipitation to determine statistical significance.

**Data source:** Climate Hazards Group Infra-Red Precipitation with Stations (CHIRPS)

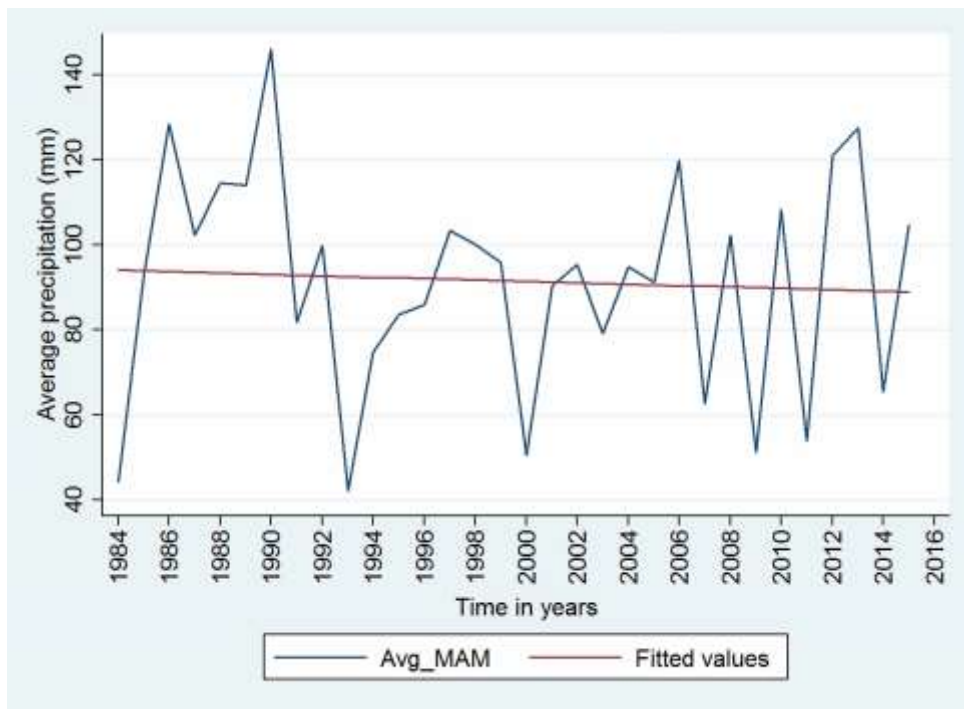
### 4.3.2 Seasonal Trends

#### 4.3.2.1 MAM Season

MAM is the long rainy season which implies that the season should record sufficient rains to sustain regeneration of vegetation due to its long duration. Further analysis involved splitting the

MAM season data into two equal parts. Here, the early years (from 1983 to 1998 period) and the later years (from 1999 to 2014 period) means were calculated and compared to test whether there was evidence of significant change ( $p < 0.05$ ). The results show that there was a decrease in the mean between the early years (from 1983 to 1998 period mean of 94.2 mm) compared to the later years (from 1999 to 2014 period mean of 89.6 mm). The difference = mean (1999 to 2014) – mean (1983 to 1998) = -4.69;  $p = 0.6832$  is a clear pointer of the decline in MAM but this was not statistically significant. A Key Informant Interviewee (2016) said that, “MAM in the last decade have recorded comparatively lower averages compared to OND”.

Figure 4.2 shows the results of a long-term linear relationship between the years and average MAM precipitation between 1984 to 2014 period for Kajiado County. The time series analysis has a negative slope which implies that there was a decline in average MAM seasonal precipitation i.e.  $= 417.4672 - 0.1630x$ . However, this decline was statistically insignificant ( $p > 0.05$ ).



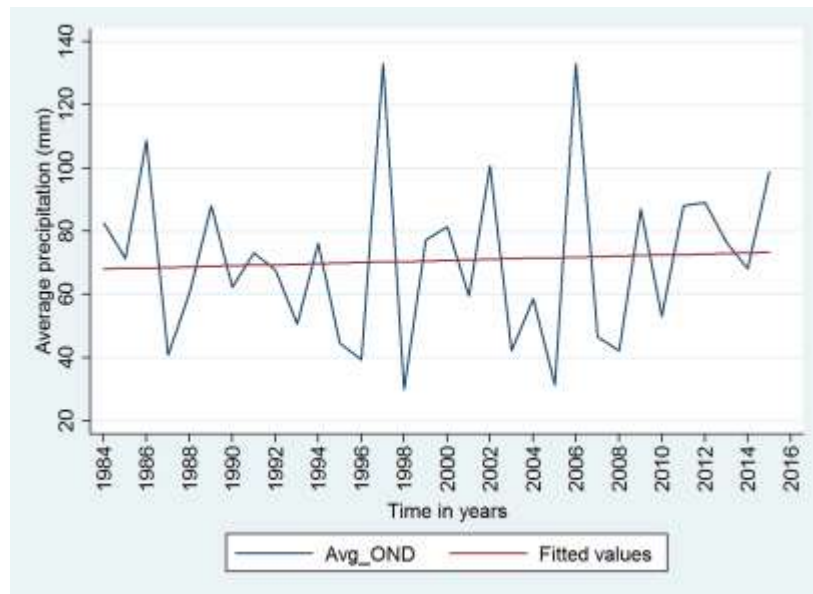
**Figure 4.2:** Average MAM seasonal precipitation trend in Kajiado County (1983-2014)

**Data source:** Climate Hazards Group Infra-Red Precipitation with Stations (CHIRPS)

### 4.3.2.2 OND Season

OND is the short rainy season which implies that the season might record insufficient rains to sustain regeneration of vegetation due to its short duration. Further analysis involved splitting the OND season data into two equal parts. Here, the early years (from 1983 to 1998 period) and the later years (from 1999 to 2014 period) means were calculated and compared to test whether there is evidence of significant change. The results demonstrate that there was an increase in the mean between the early years (from 1983 to 1998 period with a mean of 68.6 mm) compared to the later years (from 1999 to 2014 period with a mean of 71.1 mm). The difference = mean (1999 to 2014) – mean (1983 to 1998) = 2.49;  $P = 0.4024$  is a clear pointer of the increase in OND but this was statistically insignificant ( $p < 0.05$ ). This was affirmed by a Key Informant Interviewee (2016) who noted that “*there was a slight increase in rains recorded in the recent times during OND season*”.

Figure 4.3 shows the results of a long-term linear relationship between the years and average OND precipitation between the periods 1983 to 2014 for Kajiado County. The time series analysis has a positive slope which implies that there was an increase in precipitation trends i.e.  $y = 0.1685x - 2.66.299$ . However, this increase was statistically insignificant ( $p > 0.05$ ).



**Figure 4.3:** Average OND seasonal precipitation trend in Kajiado County (1983-2014)

**Data source:** “Climate Hazards Group Infra-Red Precipitation with Stations” CHIRPS

#### 4.4 Temperature Trends

Table 4.6 shows a summary of annual temperature parameters for Kajiado County in the long-term, from 1983 to 2014 period (30 years). From the findings, the average monthly temperatures were  $T_{\max}$  (25.1) and  $T_{\min}$  (14.0) °C. Further analysis involved splitting the data into two equal parts. Here, the early years (from 1983 to 1998 period) and the later years (from 1999 to 2014 period) means were calculated and compared to test whether there was evidence of significant change ( $p < 0.05$ ). The results show that there was a significant rise in the mean and (SD) for minimum temperature from the 1983 to 1998 period [13.6 (1.4)] (10.29%) compared to the 1999 to 2014 period [14.3 (1.3)] (9.09%),  $p < 0.001$ . Similarly, there was an increase in the mean and (SD) for maximum temperature from the 1983 to 1998 period [24.9 (1.8)] (CV = 7.23%) compared to the 1999 to 2014 period [25.2 (1.6)] (CV = 6.35),  $p = 0.043$ .

**Table 4.6:** Descriptive statistics for  $T_{\min}$  and  $T_{\max}$ , 1983 to 2014 overall years

Parameter	Minimum temperature			Maximum temperature		
	Long-term	1983-1998	1999-2014	Long-term	1983-1998	1999-2014
Mean	14.0	13.6	14.3	25.1	24.9	25.2
Variance	2.0	2.1	1.8	3.0	3.4	2.6
SD	1.4	1.4	1.3	1.7	1.8	1.6
Min	9.3	9.3	10.5	21.2	21.2	21.3
Q1	12.9	12.5	13.3	23.9	23.7	24.2
Median	14.2	13.8	14.7	25.0	24.7	25.2
Q3	15.1	14.7	15.4	26.4	26.4	26.5
Max	17.5	17.5	16.6	29.1	29.1	28.8
Difference			0.7			0.3
t-statistic			4.9			1.7
p-value			<0.001			0.043

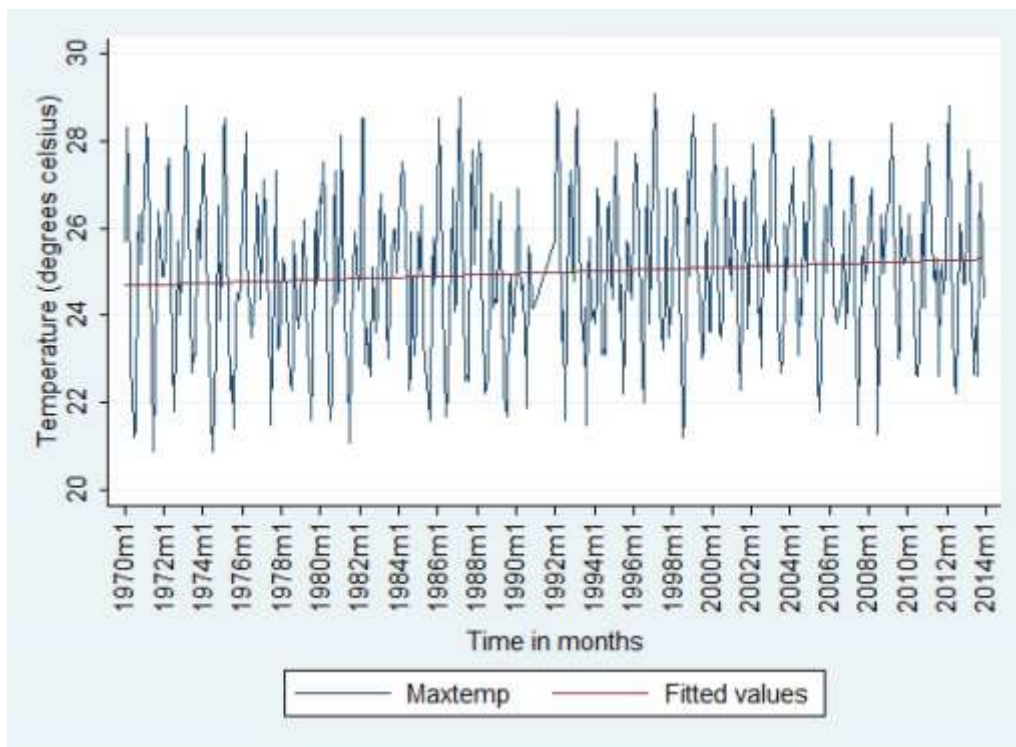
**Data source:** Kenya Meteorological Department (KMD)

##### 4.4.1 Maximum Temperature

Further analysis involved splitting the  $T_{\max}$  data into two equal parts. Here, the early years (from 1983 to 1998 period) and the later years (from 1999 to 2014 period) means were calculated and compared to test whether there was evidence of significant change. The results show that there was an increase in mean between the early years (1983 to 1998 period mean of  $T_{\max}$  24.9 °C) and

later years (1999 to 2014 period mean of  $T_{\max}$  25.2 °C). The difference = mean (1999-2014) - mean (1983-1998) = 0.32; However, this increase was statistically insignificant ( $p < 0.05$ ).

Figure 4.4 shows the results of time series showing a long-term linear relationship between the year and  $T_{\max}$  for the period 1970-2014 for Kajiado County with a positive slope which implies that there was an increase in temperature trends i.e.  $y = 0.0011x + 24.5586$ . However, this increase was not statistically significant ( $p < 0.05$ ). The Focus Group Discussions (2016) where it was reported that “*there was the increased intensity of solar radiation leading to high temperatures in the area*”.



**Figure 4.4:** Annual maximum temperature trend in Kajiado County (1970-2014) NB: M1 refers to the first month of every year across the 1970-2014 period as shown; however, all the months were used in the trend at  $p < 0.05$  for the maximum temperature to determine statistical significance.

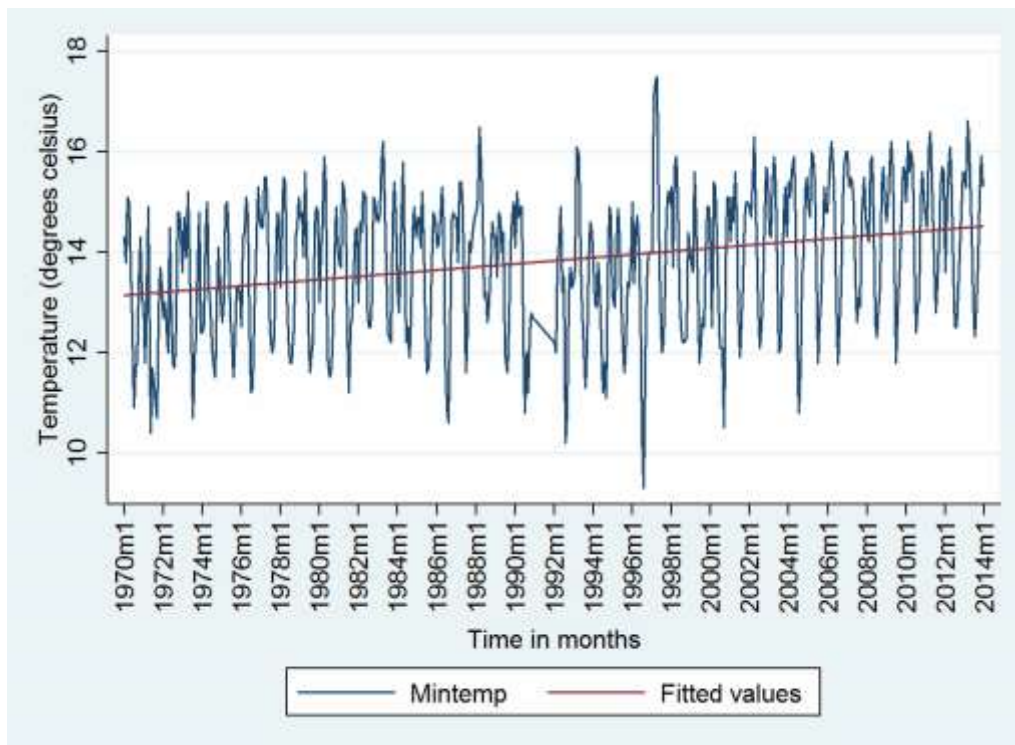
**Data source:** KMD

#### 4.4.2 Minimum Temperature

Further analysis involved splitting the data into two equal parts. Here, the early years (from 1983 to 1998 period) and the later years (from 1999 to 2014 period) means were calculated and

compared to test whether there was evidence of significant change. The results show that there was an increase in mean between the early years (from 1983 to 1998 period mean of  $T_{\min}$  13.6 °C) and the later years (from 1999 to 2014 period mean of  $T_{\min}$  14.3 °C). The difference = mean (1999-2013) – mean (1984-1998) = 0.73;  $P < 0.001$  is a clear pointer that the minimum temperature had significantly increased. This was similar to what was stated during the Focus Group Discussions (2016) which reported that “*they have been experiencing more hot nights of late compared to the earlier times*”.

Figure 4.5 shows the results of a long-term linear relationship between the years and average annual  $T_{\min}$  for the period 1970-2014 for Kajiado County. The time series analysis has a positive slope which implies that there was an increase in temperature trends i.e.  $y = 0.0026x + 12.8315$ . The rise was statistically significant ( $p < 0.05$ ).



**Figure 4.5:** Annual Minimum Temperature Trend in Kajiado County NB: M1 refers to the first month of every year across the 1970-2014 period as shown; however, all the months were used in the trend at  $p < 0.05$  for the minimum temperature to determine statistical significance.

**Data source:** KMD

#### 4.5 The Impacts of Climate Shifts on Pastoral Livelihood System

This section shows how the Maasai pastoralists in Kajiado County responded to the household surveys and it triangulates the findings with the data and information on the impacts of shifting climatic patterns to pastoral livelihoods from Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs). Table 4.7 shows a summary of the feedback on the responses obtained.

**Table 4.7:** *Impacts of climate shifts on pastoral livelihood system*

Social-economic variable indicators	Respondents (N=195)					Avg. Score
	Very great (+2)	Great (+1)	Neutral (0)	Lesser (-1)	None at all (-2)	
Emaciation	59	76	29	19	12	0.78
Small herd sizes	59	68	29	20	19	0.68
Pasture deficit	59	72	23	25	16	0.69
Disease prevalence	53	72	45	15	10	0.74
Restricted grazing	53	53	47	27	15	0.51
Distorted culture	51	49	51	31	13	0.46
Disjuncture to markets forces	51	57	45	25	17	0.49
Disrupted calendar timelines	59	57	35	21	23	0.57

**Explanation:** *Perception survey scale on attitude is awarded or affirmed when the mean score >0; weak or dissatisfied when the mean score <0*

The Maasai pastoralists had noticed that their herds were getting emaciated due to the adverse effects of the shifting climatic patterns. The results based on the 5-point Likert scale showed that the average score was 0.78 on a survey scale of perception. The Likert scale was distributed as follows; very great; 30 per cent (59), great; 39 per cent (76), neutral; 10 per cent (29), lesser; 15 per cent (19) and none at all; 6 per cent (12). This implies that the majority of the pastoralists were aware of increased cases of weight loss in their herds. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported that “*there were concerns of underweight herds which were fetching low market prices*”. Similarly, Focus Group Discussions (2016) reported that “*their productions were declining thus reducing their disposable income*”.

The results indicate that herd sizes were declining at an average score of 0.68 on a survey scale of perception. The Likert scale was distributed as follows; very great; 31 per cent (59), great; 35 per cent (68), neutral; 15 per cent (29), low; 10 per cent (20) and none at all; 9 per cent (19). This implies that the majority of the pastoralists were aware that their herds' population were on a declining trend. This observation was reaffirmed by Focus Group Discussions (2016) which reported that *"the harsh climatic conditions were becoming unbearable for their livestock resulting in deaths"*.

The results show that pasture deficit months had increased at an average score of 0.69 on a survey scale of perception. The Likert scale was distributed as follows; very great; 30 per cent (59), great; 37 per cent (72), neutral; 12 per cent (23), low; 13 per cent (25) and never; 8 per cent (16). This implies that the majority of the pastoralists were aware that palatable pastures had declined in the area. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported that *"palatable vegetation species were dwindling at the expense of the invasive species"*. Similarly, Focus Group Discussions (2016) reported that *"the rising temperatures favour the proliferation of invasive species in the area"*.

The results indicate the high cost of maintaining livestock due to disease outbreaks at an average score of 0.74 on a survey scale of perception. The Likert scale was distributed as follows; very great; 27 per cent (53), great; 37 per cent (72), neutral; 23 per cent (45), low; 8 per cent (15) and never; 5 per cent (10). This implies that the majority of the pastoralists were aware of the incurring high costs in managing the rising incidences of livestock diseases. This observation was reaffirmed by Focus Group Discussions (2016) which reported that *"the Maasai's are having challenges in containing livestock diseases due to the high cost of treatment"*. Similarly, a Key Informant Interviewee (2016) reported that *"the herds have low resistance to diseases as a result of poor nutritional status causing increased cases of disease outbreaks in the area to the point of overwhelming the capacity of the community health workers"*.

The results show that grazing cycles had been interrupted at an average score of 0.51 on a survey scale of perception. The Likert scale was distributed as follows; very great; 27 per cent (53), great; 27 per cent (53), neutral; 24 per cent (47), rarely; 14 per cent (27) and never; 8 per cent (15). This implies that the majority of the pastoralists were aware that traditional mobility of livestock has been curtailed due to seasonal failures. This observation was reaffirmed by Focus Group



Discussions (2016) which reported that *“traditional seasonal movement of livestock is threatened by unpredictable climate patterns”*. Similarly, a Key Informant Interviewee (2016) reported that *“individuals have had to trek longer distances with their livestock beyond their territorial boundaries to access pasture”*.

The results indicate that there were uncertainties in the observation of cultural rites at an average score of 0.46 on a survey scale of perception. The Likert scale was distributed as follows; very often; 26 per cent (51), regular; 25 per cent (49), neutral 26 per cent (51), rarely; 16 per cent (31) and never; 7 per cent (13). This implies that the majority of the pastoralists were aware that they were having difficulties in upholding cultural rites of passage. This observation was reaffirmed by Focus Group Discussions (2016) which reported that *“there were many instances where customary rites of passage were aborting due to seasonal failures”*.

The results indicate non-conformity to the market forces at an average score of 0.49 on a survey scale of perception. The Likert scale was distributed as follows; very often; 26 per cent (51), regular; 29 per cent (57), neutral; 23 per cent (45), rarely; 13 per cent (25) and never; 9 per cent (17). This implies that the majority of the pastoralists were aware of the trending purchasing powers in the markets but disapproved of them. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported that *“the locals have reservation to selling their herds but only do so during a dry spell which attracts low market prices”*. Similarly, Focus Group Discussions (2016) reported that *“livestock is a symbol of wealth. Therefore, the locals cherish large herds and only dispose of their animals as the last resort and as such that has resulted in economic marginalisation”*.

The results indicate dissolution of engagements at an average of score of 0.57 on a survey scale of perception. The Likert scale was distributed as follows; very often; 30 per cent (59), regular; 29 per cent (57), neutral 18 per cent (35), rarely; 11 per cent (21) and never; 12 per cent (23). This implies that the majority of the pastoralists were aware of the uncertainties in their calendar of activities. This observation was reaffirmed by the Focus Group Discussions (2016) which reported that *“certain events that require lush pastures could not be actualised since soothsayers are having difficulties in making accurate predictions”*. Similarly, a Key Informant Interviewee (2016) reported that *“extinction certain species of animals and plants have left the community even more confused to undertake age group rituals”*.

Additionally, Chi-Square statistics were computed in various segments to examine the dependence and relationship among the various groups of variables as shown in Table.4.8.

The  $\chi^2$  computed (48.829) was greater than  $\chi^2$  critical (16.928). Thus, the null hypothesis, “social-economic variables are independent of shifting climatic patterns” is rejected. It is, thus, credible that social-economic variables including Maasai pastoralists’ ability to access adequate food in Kajiado County is affected by the shifting climatic patterns. This might be attributed to the climate-sensitive nature of pastoral livelihood system due to its great dependency on the natural resources whose variation is of great concern according to the local Maasai pastoralists.

**Table 4.8:** *Shift in climatic patterns and its impacts on pastoral livelihood*

Social-economic indicator variables	Chi-Square calculations					
	VG	G	N	LE	NA	(O - E) <sup>2</sup> /E
Emaciation	0.161	2.683	2.132	0.686	1.333	6.995
Small herd sizes	0.161	0.397	2.132	0.391	0.563	3.644
Pasture deficit	0.161	1.286	5.921	0.174	0.000	7.542
Disease prevalence	0.161	1.286	1.289	2.783	2.250	7.769
Restricted grazing	0.161	1.587	2.132	0.696	0.062	4.638
Distorted culture	0.446	3.111	4.447	2.783	0.563	11.35
Disjuncture to markets forces	0.446	0.632	1.289	0.174	0.063	2.604
Disrupted calendar timelines	0.161	0.632	0.257	0.174	3.063	4.287
$\chi^2$						48.829

**Data source:** Author’s survey, 2016

**Key:**

VG = Very great; G = Great; N = Neutral; LE = Less extent; NA = None of all;  $\chi^2$  = Chi-Square  
 Provided that the level of significance  $\alpha = 5\%$  while the degree of freedom - 28 = df.

## 4.6 Discussion

Evaluation of education levels as shown in Table 4.4 revealed that it influenced the households' ability to cope with adverse impacts of climate change. Those with formal education had the advantage of seeking for information at the onset of the hazards and responded faster while households with no formal education took a longer time to respond when disaster strikes. Gbetibouo (2009) reported that education increases adaptive capacity by increasing and enhancing people's ability to cope with adversities. The study established that dropout rates at primary school levels were high due to pasture deficit which forced the school-age going children to drop out of school to take care of the herds. They also have to travel long distances to access pasture hence they are unable to attend school. Moreover, the available schools are in fixed locations which contradict their mobility needs thus contributing to the relatively high number of under-educated among the Maasai people in comparison to the national average. Kiragu and Warrington (2012) established similar findings and they reported that a large number of the Maasai population were under-educated compared to the national average. Cutter *et al.* (2003) reported that low levels of education constrain people's ability to comprehend warning information. Therefore, a low level of education has hindered the Maasai pastoralists' ability to respond quickly to shift in climatic patterns.

The majority of the participants who were engaged in the surveys were the elderly compared to the other age groups since they were more familiar with the Maasai traditions. The study noted that age-related complications limit the elderly from cushioning their families against the adverse climate change impacts. The situation is not any different in female-headed households because the female is more vulnerable due to gender discrimination. The mature Maasai women were generally passive during the discussions as compared to their male counterparts because unlike the youths, senior youths and men who have a role to perform in the conservation of natural resources, the women and children are not consulted when decisions on the nurturing of natural resources are being made. The patriarchal nature of this community dictates that women take a back seat when it comes to decision making which renders them vulnerable. Despite the cultural disposition, there has been concerted effort by Non-Governmental Organisations aimed at promoting girl child education which has contributed to the number of women who are now involved in decision making in the communities. However, it is important to note that the Maasai community is still highly patriarchal as noted by Western and Nightingale (2003).

Rainfall is one of the most essential climate attributes because it determines the type of vegetation cover of a given area which then makes it suitable for livestock to survive even in a dryland ecosystem. The findings indicated that the annual rains had declined but not significantly while the seasonal patterns had become unpredictable with OND becoming wetter compared to MAM. Similarly, Bobadoye *et al.* (2016); Jaetzold *et al.* (2011); Behnke (2000); Behnke and Scoones (1993) and Mace (1991) reported unreliability of precipitation patterns in the area. Liebmann *et al.* (2014); Amwata *et al.* (2016); GoK (2012); GoK (2016) and Liebmann *et al.* (2014) also noted that the short rains (OND) had slightly increased as compared to the long rains (MAM) over the last decade.

Temperature is an important climate attribute just like rainfall. It influences the rate of evaporation and moisture levels in the soil and the adverse effects of high temperatures are largely felt in the dryland ecosystem. The findings indicated that both the maximum ( $T_{\max}$ ) and minimum ( $T_{\min}$ ) temperatures had risen. The maximum temperature had risen from 24.9 to 25.2°C while the minimum temperature had risen from 13.6 to 14.3°C. This was an increase of between 0.3 and 0.7 °C respectively. Christy *et al.* (2009) and Said *et al.* (2017) had also reported that the average temperatures of the area were rising. These observations are consistent with the findings of GoK (2010) who stated that the maximum temperatures had risen by a margin of between 0.2 and 1.3°C while minimum temperatures had risen by a margin of 0.7 to 2.0°C on average across the area.

The impacts of shifting climatic patterns on pastoral livelihoods were noticeable. The rising temperatures had a negative effect on seasonal timelines such as increasing the duration of dry spell. Similarly, Sein *et al.* (2015) noted that the increase in temperature had a direct correlation to failures of both rainfall seasons. The IPCC (2007) and IPCC (2014) also affirmed that a rise in temperatures could be accompanied by drastic shifts in climate and the negative impacts could worsen with time. A rise in temperature beyond 1.5°C is associated with a trail of devastations such as floods and droughts (IPCC, 2007) yet IPCC (2014) reported that the East African region, where the County is located, had a rise of 0.5 to 2°C in its surface temperature. Kajiado County is in a water-scarce region and rising temperatures could render its soils drier due to the high evaporation rates attributed to temperature rise. Indeed, dry soil cannot sustain any form of vegetation regeneration rendering its landscape unproductive. Similarly, Said *et al.* (2017) reported that extended length of dry spell could leave the Maasai pastoralists with less time for recovery

before another drought episode strikes. This implies that the severity of droughts could worsen in the future as temperatures increase in the area. As such, thermal extremes could lead to the shrinking natural resources as most palatable pasture species get extinct. This opinion is supported by Burnsilver *et al.* (2003) who restated that climate shift could threaten environmental goods and services such as wildlife and other accrued benefits which have been sustained over generations.

The findings show that shifting climatic patterns had adverse implications on herds' body weight, herd sizes, pasture deficit months, disease management costs, grazing cycles, market forces and cultural events. The depletion of natural resources including water and pasture are attributed to climate change since it influences their spatial distribution. According to the responses from the household surveys, FGDs and KIIs, livestock rearing was adversely impacted considering the uncertainties in the climatic conditions as the Maasai pastoralists were ill prepared to mitigate the risks. Furthermore, they were spending more time searching for water and pasture which has impacted on the seasonal grazing pattern. In spite of these challenges, the Maasai pastoralists have continued using traditional rotational grazing patterns. The herders have been moving across the landscape in search of pasture and water despite the observed changes in climate trend which could interrupt migration and adversely impact the livestock production system (Mukuna *et al.*, 2015) as was reflected in the emaciated herds or reduced herd sizes in this study. GOK (2012) also reported similar disruptions in rotational grazing which is attributed to seasonal failures. Robinson *et al.* (2014) noted that a rise in temperature could have adverse consequences on livestock forage intake, growth, mortality, reproduction, production and maintenance. Similar sentiments were reported by OleSaitabau (2014) who noted that the rapid rate at which the maximum temperature was rising could be a threat to the traditional production system. As such, the rising temperatures could disrupt pasture regeneration leading to distortion of traditional cyclic migration patterns to a point where the pastoral livelihood system will become unsustainable.

The shifting climatic patterns dictate that the *morans*<sup>25</sup> migrate extensively with their herds to offset pasture and water deficits. Therefore, the *morans* have had to migrate with their herds far beyond their territorial boundaries and over an extended period. Similarly, Marius (2012) reported that pastoralists have had to extend their migration space beyond the traditional cyclic routes. As

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<sup>25</sup> Morans - the male Maasai youths

such, the community has been faced with a myriad of problems including social interference as the *morans* are separated from their families for a long duration which leaves their women, children and the elderly vulnerable without a reliable source of food. This observation is similar to that reported by Catley *et al.* (2013) and Ng'ang'a *et al.* (2016) who noted an increase in food insecurity cases and rising malnutrition levels among the Maasai pastoralists since there was low production of milk and meat. Similarly, Mapiye *et al.* (2006) reported low production of milk and meat in the area. Therefore, the Maasai community is faced with multiple production and economic hurdles (Ericksen *et al.*, 2013; Ashton, 2002).

#### **4.7 Conclusion**

Kajiado County has experienced a rapid shift in its climatic conditions which has been characterised by rainfall variability, unreliable seasonal patterns and high temperatures. These occurrences have had adverse impacts on the pastoral livelihood as manifested by water scarcity and pasture deficiency. Furthermore, there has been the death of livestock, which is a clear pointer to the fact that the Maasai pastoralists are faced with multiple challenges which require timely intervention. In spite of the above-mentioned constraints, the study established that the Maasai herders have made frantic efforts to sustain their production system. However, the shifting climatic patterns have rendered some of their efforts ineffective as they have ended up with persistent water and pasture deficits as demonstrated in “Land Use and Land Cover Changes” in the next chapter.

## CHAPTER FIVE

### EVALUATION OF PASTORAL SOCIAL-ECOLOGICAL SYSTEM AND ITS INFLUENCE ON THE PASTORAL LIVELIHOOD SYSTEM

#### 5.1 Introduction

This chapter presents results on Land Use and Land Cover mapping between the years 1987 to 2015. These results are in the form of maps and tables showing LULC<sup>26</sup> changes in areas in hectares for the various LULC types. Included is also the results on people's responses from surveys on "land cover and land use" compatibility. Lastly, the results from the household surveys were triangulated with the data and information from the Key Informant Interviews and Focus Group Discussions on impacts of LULC changes to pastoral livelihood system.

#### 5.2 Statistics for Land Use and Land Cover

Table 5.1 shows results using 1987 as the initial year (past) and 2015 as the final year (present) with the changes under the various LULC computed in hectares. There were gains in bare area (1,387), built-up area (615), cropland (14,914), grassland (211,573) and forestland (9,870) and loses in riverine (-922), shrubland (-235,925) waterbody (-216) and wetland (-1,304).

**Table 5.1:** *LULC changes from 1987 to 2015*

S/No.	LULC Types	Area (Hectares)		
		Year: 1987	Year: 2015	Change (1987-2015)
1.	Bare area	55,130	56,518	1,387
2.	Built-up	327	942	615
3.	Cropland	15,383	30,296	14,914
4.	Forestland	55,372	65,242	9,870
5.	Grassland	480,016	691,589	211,573
6.	Riverine	9,293	8,370	-922
7.	Shrubland	1,560,841	1,324,916	-235,925
8.	Water body	9,862	9,647	-216
9.	Wetland	3,849	2,545	-1,304

**Data source:** [www.glovis.usgs.org](http://www.glovis.usgs.org)

<sup>26</sup> Land Use Land Cover

Table 5.2 shows results using 1987 as the initial year (past) and 2000 as the final year (near present) with the changes under the various LULC computed in hectares. There were gains in built-up area (346), cropland (8,614), grassland (129,952), forestland (4,015) and water body (1,307) and loses in bare area (-6,453), riverine (-2,715), shrubland (-134,141) and wetland (-862).

**Table 5.2:** *LULC changes from 1987 to 2000*

S/No	LULC Types	Area (Hectares)		
		Year: 1987	Year: 2000	Change (1987 to 2000)
1.	Bare area	55,130	48,677	-6,453
2.	Built-up area	327	673	346
3.	Cropland	15,383	23,997	8,614
4.	Forestland	55,372	59,387	4,015
5.	Grassland	480,016	609,968	129,952
6.	Riverine	9,293	6,578	-2,715
7.	Shrubland	1,560,841	1,426,700	-134,141
8.	Water body	9,862	11,170	1,308
9.	Wetland	3,849	2,987	-862

**Data source:** [www.glovis.usgs.org](http://www.glovis.usgs.org)

Table 5.3 shows results using 2000 as the initial year and 2015 as the final year with the changes under the various LULC computed in hectares. There were gains in bare area (7,841), built-up area (269), cropland (6,299), grassland (81,621), forestland (5,855) and riverine (1,792) and loses in shrubland (-101,784) waterbody (-1,523) and wetland (-442).

**Table 5.3:** *LULC change from 2000 to 2015*

S/No.	LULC Types	Area (Hectares)		
		Year: 2000	Year: 2015	Change (2000-2015)
1.	Bare area	48,677	56,518	7,841
2.	Built-up area	673	942	269
3.	Cropland	23,997	30,296	6,299
4.	Forestland	59,387	65,242	5,855
5.	Grassland	609,968	691,589	81,621
6.	Riverine	6,578	8,370	1,792
7.	Shrubland	1,426,700	1,324,916	-101,784
8.	Water body	11,170	9,647	-1,523
9.	Wetland	2,987	2,545	-442

**Data source:** [www.glovis.usgs.org](http://www.glovis.usgs.org)



Table 5.4 shows the results of changes in the area when the study period was split into two equal intervals between the early years (from 1987-2000 period) and later years (from 2000-2015 period). There were relative absolute changes in the magnitude at which land use change was taking place in the areas under the various LULC types. The results show relatively less changes in the status of the bare area, forestland and waterbody and more changes in the status of built-up areas, cropland, grassland, shrubland and wetland in the early years (from 1987-2000 period) compared to later years (from 2000 to 2015 period).

**Table 5.4:** *LULC change comparison in hectares between the early (1987-2000) and later (2000-2015) period*

S/No.	LULC Types	Change comparison in Hectares	
		(1987-2000)	(2000-2015)
1.	Bare area	6,453	7,841
2.	Built-up area	346	269
3.	Cropland	8,614	6,299
4.	Forestland	4,015	5,855
5.	Grassland	129,952	81,621
6.	Riverine	2,714	1,792
7.	Shrubland	134,141	101,784
8.	Water body	1,308	1,523
9.	Wetland	1,524	442

**Data source:** [www.glovis.usgs.org](http://www.glovis.usgs.org)

The results above were based on the processed Landsat 8, 5 and 4 satellite imagery available as open sources from [www.glovis.usgs.org](http://www.glovis.usgs.org) supported by NASA<sup>27</sup>. These datasets were used to generate land cover maps based on the Food and Agriculture Organization Land Classification System for the years 1987, 2000 and 2015. Based on these Land Use and Land Cover maps, the extent of changes were detected for the different time intervals covering 1987 to 2000, 2000 to 2015 and 1987 to 2015. Figure 5.1, Figure 5.2 and Figure 5.3 show the Land Use and Land Cover maps which were subjected to validation using simple points collected from high-resolution imageries from Google Earth as ground truth data. These Land Use and Land Cover maps captured

<sup>27</sup> National Aeronautics and Space Administration

the nine LULC types, namely: built-up area, bare area, cropland, forestland, riverine, grassland, shrubland, water body and wetland across the entire Kajiado County.

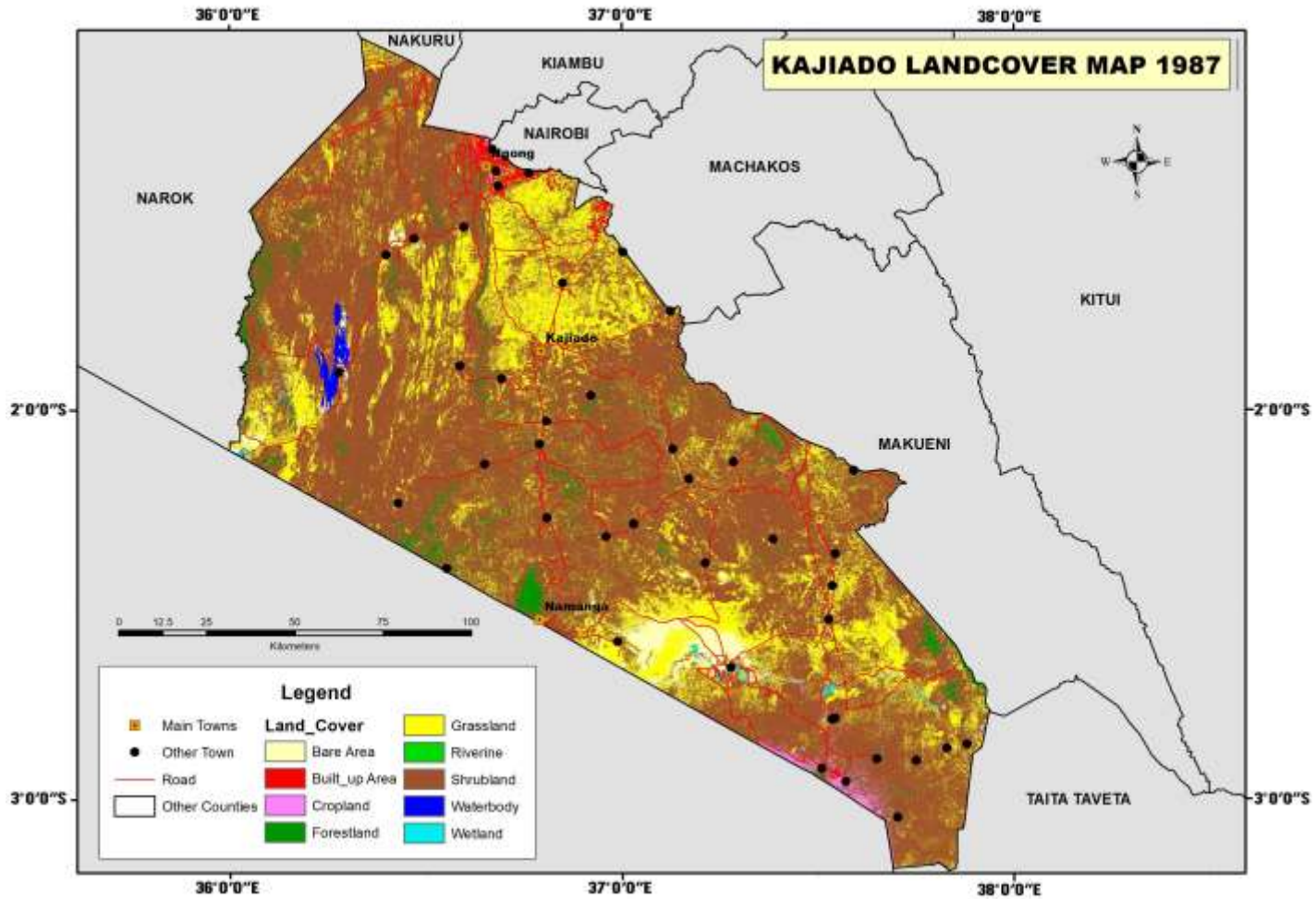
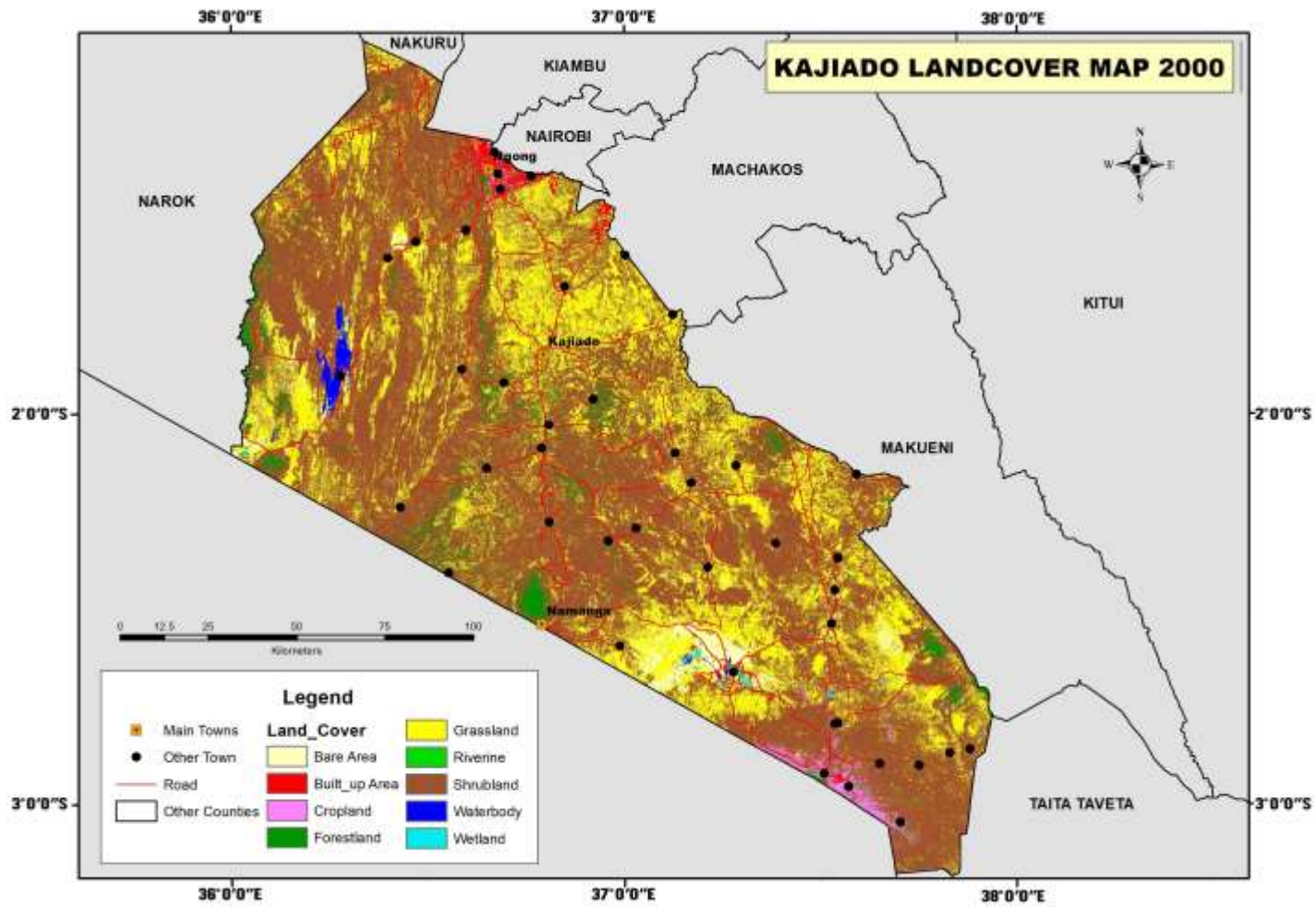


Figure 5.1: Kajiado County Land Cover Map 1987

Data source: [www.glovis.usgs.org](http://www.glovis.usgs.org)



**Figure 5.2:** Kajiado County Land Cover Map 2000

Data source: [www.glovis.usgs.org](http://www.glovis.usgs.org)

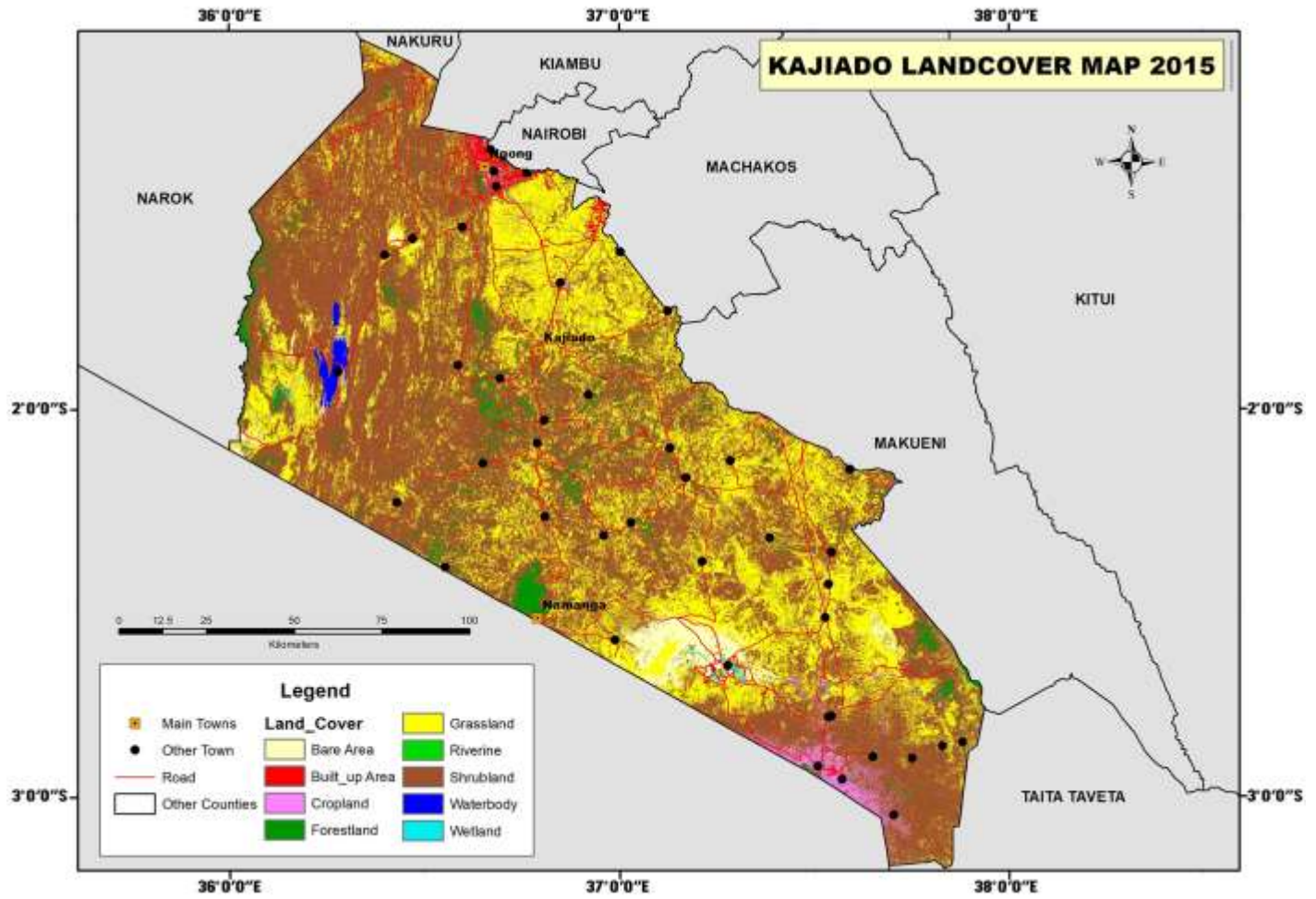


Figure 5.3: Kajiado County Land Cover Map 2015

Data source: [www.glovis.usgs.org](http://www.glovis.usgs.org)

### 5.3 LULC Rate of Change per Year

Table 5.5 displays the results based on the percentage rate of change for the three periods namely 1987 to 2000, 2000 to 2015 and 1987 to 2015.

**Table 5.5:** *Percentage rate of change*

No.	LULC Types	Percentage rate of change in Ha/year		
		1987-2000	2000-2015	1987-2015
1.	Bare area	-0.90	1.07	0.09
2.	Built-up	0.08	2.67	6.72
3.	Cropland	0.04	1.75	3.46
4.	Forestland	0.01	0.66	0.64
5.	Grassland	0.02	0.89	1.57
6.	Riverine	0.02	1.82	-0.35
7.	Shrubland	0.06	-0.48	-0.54
8.	Water body	0.01	-0.91	-0.08
9.	Wetland	0.02	-0.99	-1.21

**Explanation:** The positive (+) sign means increase while the negative (-) sign means a decrease in the area of LULC type.

**Data source:** [www.glovis.usgs.org](http://www.glovis.usgs.org)

### 5.4 Land use Transformation and Compatibility to Pastoral Livelihoods

This section shows how the Maasai pastoralists in Kajiado County responded to the household survey and it is triangulated with the data and information on land use and its compatibility to pastoral livelihoods. It also includes results from Focus Group Discussions and Key Informant Interviews. Table 5.6 shows a summary of the responses obtained.

The Maasai pastoralists were likely to settle next to the water body at an average score of 0.54 on a survey scale of perception. The Likert scale was distributed as follows; very great; 30 per cent (59), great; 29 per cent (57), neutral; 18 per cent (35), lesser; 11 per cent (21) and none at all; 12 per cent (23). This implies that the majority of the pastoralists were aware of water scarcity in the area and the limited access to habitual pastoral living space. The pastoralists also know that proximity to a water body is critical for their survival. This observation was reaffirmed by the Focus Group Discussions (2016) which reported that “*water is a critical resource and given a*

*choice, the Maasai pastoralists would prefer to settle at a place where they will have proximity to a water body”.*

The results show that the Maasai pastoralists were uncomfortable at the mention of conservancies at an average score of -0.57 on a survey scale of perception. The Likert scale was distributed as follows; very great; 7 per cent (14), great; 16 per cent (30), neutral; 20 per cent (39), lesser; 27 per cent (53) and none at all; 30 per cent (59). This implies that the majority of the pastoralists were aware of conservancies in their backyard but they disapproved of their setting due to the restrictions imposed to them. This observation was reaffirmed by the Focus Group Discussions (2016) which reported that *“conservancies were unnecessary since they have restricted their habitual open grazing space thus denying the locals access to pasture”*. Similarly, a Key Informant Interviewee (2016) reported that *“the locals have been accused of trespass in conservancies and resulted in the territorial rivalry between the Maasai pastoralists and conservancies’ management”*. The law addressed this conflict through the Community Land Act, 2016 though most Maasai pastoralists are not aware of its existence.

The results indicate that the Maasai pastoralists were uncomfortable with the agricultural practices at an average score of -0.40 on a survey scale of perception. The Likert scale was distributed as follows; very great; 15 per cent (19), great; 11 per cent (21), neutral; 19 per cent (39), lesser; 29 per cent (57) and none at all; 26 per cent (51). This implies that the majority of the pastoralists were aware that the area under crop had expanded despite water scarcity in the area. This observation was reaffirmed by the Focus Group Discussions (2016) which reported that *“the surface water levels were declining drastically and this is attributed to an increase in water demand by the expanding agricultural activities”*. Similarly, a Key Informant interviewee (2016) reported that *“the locals relied on rain-water to recharge their surface water and the expanding agricultural activities could make the already bad situation worse”*.

The results indicate that the Maasai pastoralists recognized the legitimacy of the national parks in their backyard at an average score of 0.61 on a survey scale of perception. The Likert scale was distributed as follows; very great; 30 per cent (59), great; 33 per cent (64), neutral; 13 per cent (25), lesser; 16 per cent (31) and none at all; 8 per cent (16). This implies that the majority of the pastoralists were aware of the national parks and affirmed their role in the conservation effort, and as such, they accorded them respect. This observation was echoed in the Focus Group Discussions

(2016) where it was noted that *“the community has benefited from social-corporate programmes from the Kenya Wildlife Services”*.

The results show that the Maasai pastoralists appreciated the role played by the forest reserves in their backyard at an average score of 0.60 on a survey scale of perception. The Likert scale was distributed as follows; very great; 33 per cent (64), great; 30 per cent (59), neutral; 14 per cent (27), lesser; 10 per cent (20) and none at all; 13 per cent (25). This implies that the majority of the pastoralists were aware of forest reserves and affirmed that they co-existed with them in their backyards. This observation was also reported by the Focus Group Discussions (2016) which noted that *“there were ecosystem related benefits from the forests which were extended by reserves management to the Maasai community where they were allowed to access the forest during drought episodes”*.

The results indicate that the Maasai pastoralists appreciated upcoming urban centres at an average score of 0.43 on a survey scale of perception. The Likert scale is distributed as follows; very high; 30 per cent (59), high; 26 per cent (51), neutral; 14 per cent (27), low; 17 per cent (33) and none at all; 13 per cent (25). This implies that the majority of the pastoralists were aware of the infrastructure developments in their surroundings. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported that *“the government has played an important role in putting up various infrastructures in the area including improvement on roads and building up new market centres at strategic location to open up the area for development”*. Similarly, the Focus Group Discussions (2016) reported that *“urban centres have helped open up the area for further development”*.

**Table 5.6:** *Land cover and use compatibility to pastoral livelihood*

Land uses	Respondents (N=195)					Avg. Score
	Very great	Great	Neutral	Lesser	None at all	
Waterbody	59	57	35	21	23	0.54
Conservancies	14	30	39	53	59	-0.57
Crop farming	29	21	37	57	51	-0.40
National parks	59	64	25	31	16	0.61
Forest reserves	64	59	27	20	25	0.60
Urban centres	59	51	27	33	25	0.43

**Explanation:** *Perception survey scale on attitude is awarded or affirmed when the mean score >0; weak or dissatisfied when the mean score <0*

**Data source:** Author's survey, 2016; table generated by the Author

Additionally, Chi-Square statistics were computed in various segments to examine the dependence and relationship among various groups of variables as shown in Table. 5.7.

The  $\chi^2$  computed (158.31) was greater than  $\chi^2$  critical (10.851). Therefore, the null hypothesis that, “the use compatibility is independent on pastoral livelihood” is rejected. It is, therefore, conceivable that the pastoral livelihood system is in harmony with the various land uses within this ecosystem. This might have been attributed to the sustenance of conservation measures within nomadic pastoralism.



**Table 5.7: Pastoral livelihood compatibility to the land use transformation**

Compatibility variable indicators	Chi-square calculations					
	VG	G	N	LE	NA	(O - E) <sup>2</sup> /E
Waterbody	3.06	2.13	0.28	6.25	3.03	14.75
Conservancies	23.17	6.15	1.53	8.03	20.48	59.36
Crop farming	6.89	14.38	0.78	12.35	9.82	44.22
National parks	3.06	6.15	1.53	0.69	8.76	20.19
Forest reserves	6.15	3.06	0.78	7.11	1.94	12.8
Urban centres	3.06	0.34	0.78	0.25	2.56	6.99
$\chi^2$						158.31

**Data source:** Author's survey, 2016

**Key:**

VG = Very great; G = Great; N = Neutral; LE = Less extent; NA = None at all; Chi-square =  $\chi^2$

Provided that the level of significance  $\alpha = 5\%$  while the degree of freedom - 20 = df.

### 5.5 The Impacts of Land Use Transformation to the Pastoral Livelihood System

This section shows how the Maasai pastoralists in Kajiado County responded to the household surveys and it triangulates them with the data and information on impacts of LULC changes on pastoral livelihood system from Key Informant Interviews and Focus Group Discussions. Table 5.8 shows a summary of the responses obtained.

The Maasai pastoralists inhabit an area which lacks clear demarcations at an average score of - 0.35 on a survey scale of perception. The Likert scale was distributed as follows; very high; 17 per cent (33), high; 12 per cent (24), neutral 17 per cent (33), low; 22 per cent (43) and never; 32 per cent (62). This implies that the majority of the Maasai pastoralists had cognisant of obscure boundaries. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported

that “*certain individuals have taken advantage of unclear demarcations to grab land far beyond their registered acreage. Similarly, Focus Group Discussion (2016) reported that “the transboundary nature of natural resources makes unclear boundary demarcations inevitable”.*

The results indicate that the Maasai pastoralists were experiencing receding water levels in their water resources at an average score of 0.32 on a survey scale of perception. The Likert scale was distributed as follows; very high; 26 per cent (51), high; 30 per cent (58), neutral; 19 per cent (37), low; 18 per cent (35) and none at all; 7 per cent (14). This finding implies that the majority of the pastoralists were aware of the scarcity of water in the area. This observation was reaffirmed in the Focus Group Discussions (2016) where it was reported that “*surface water distribution channels were receding*”. A Key Informant Interviewee (2016) reported that “*the Government established that there was over-abstraction of water for irrigation upstream and Water Resources Authority (WRA) has been closing illegal diversion of water to allow people access to water*”. The results show that the Maasai pastoralists abhor enclosure at an average score of -0.64 on a survey scale of perception. The Likert scale was distributed as follows; very great; 5 per cent (10), great; 12 per cent (23), neutral 27 per cent (53), lesser; 26 per cent (50) and none at all; 30 per cent (59). This implies that the majority of the pastoralists were aware of fencing in some sections but expressed their disapproval of it since it restricted their mobility needs. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported that “*fencing curtails open access to natural pastures*”. Similarly, it was reported in the Focus Group Discussions (2016) that “*the fencing off of land is not in harmony to nomadic pastoralism and it makes key natural resources inaccessible*”.

The results indicate that the Maasai pastoralists abhor sedentary lifestyle in the form of resettlement at an average score of -0.54 on a survey scale of perception. The Likert scale was distributed as follows; very great; 6 per cent (12), great; 15 per cent (29), neutral; 27 per cent (53), lesser; 24 per cent (47) and none at all; 28 per cent (54). This implies that majority of the Maasai pastoralists were losing their habitual pastoral grazing space as strategic resources were being alienated from the community for exclusive private use in resettlement operations. This observation was reaffirmed in the Focus Group Discussion (2016) where it was reported that “*resettlement limits the locals’ access to critical resources since it creates exclusivity in the land*

use”. Similarly, a Key Informant Interviewee (2016) reported that “*sedentary lifestyle is not in harmony with the nomadic pastoralism which thrives in open space*”.

The results show that the Maasai pastoralists had noticed that invasive species had invaded the area at an average score of 0.56 on a survey scale of perception. The Likert scale was distributed as follows; very high; 31 per cent (60), high; 31 per cent (60), neutral; 9 per cent (18), low; 22 per cent (43) and none at all; 7 per cent (14). This implies that the majority of the pastoralists were aware of the proliferation of invasive species in the area. This observation was reaffirmed during the Focus Group Discussions (2016) where it was reported that “*palatable pasture species were shrinking which has led to reduced production in the area*”. Similarly, a Key Informant Interviewee (2016) reported that “*invasive species have proliferated of *Cinchrus ciliaris*, *Prosopis juliflora* and *Ipomoea spp.* in large areas*”.

**Table 5.8:** Impacts of land use transformation to the pastoral livelihood system

Impacts	Respondents (N=195)					Avg. Score
	Very high (+2)	High (+1)	Neutral (0)	Low (-1)	Never (-2)	
Trans-boundary resources	33	24	33	43	62	-0.35
Receding water resources	51	58	37	35	14	0.32
Enclosure	10	23	53	50	59	-0.64
Settlements	12	29	53	47	54	-0.54
Invasive species	60	60	18	43	14	0.56

**Explanation:** Perception survey scale on attitude is awarded or affirmed when the mean score  $>0$ ; weak or dissatisfied when the mean score  $<0$

**Data source:** Author’s survey, 2016

Additionally, Chi-Square statistics were computed in various segments to examine the dependence and relationship between various groups of variables as shown in Table.5.9.

The  $\chi^2$  computed (180.21) is greater than  $\chi^2$  critical (7.962). Therefore, the null hypothesis which states that “sustainability of pastoral livelihood is independent of land use transformation” is rejected. It is, therefore, conceivable that land use transformation has constrained mobility among the Maasai pastoralists in Kajiado. This might be attributed to factors such as emerging private land ownership since significant areas have shifted from communal land registration to private holding.

**Table 5.9:** *Impacts of land use transformation on pastoral livelihood system*

Transformation indicators	Chi-Square calculations					
	VH	H	N	L	N	(O - E) <sup>2</sup> /E
Trans-boundary resources	0.00	5.77	0.92	0.02	10.76	17.47
Receding water resources	9.82	9.26	0.10	1.84	17.78	38.8
Enclosure	16.03	6.56	5.03	0.82	7.90	36.34
Settlements	13.36	2.56	5.03	0.20	4.12	25.09
Invasive species	22.09	11.31	11.31	0.02	17.78	62.51
$\chi^2$						180.21

**Data source:** Author’s survey, 2016

**Key:**

Vh = Very high, H = High, N = Neutral, L = Low, N = Never;  $\chi^2$  = Chi-Square

Provided that the level of significance  $\alpha = 5\%$  while the degree of freedom - 16 = df

## 5.6 Discussion

In the past, most of the land in Kajiado County was largely registered under communal land ownership which supported livestock production. However, the area has undergone significant transformation aggravated by private holdings and land subdivision. This observation is similar to that of Catley *et al.* (2013) who noted that significant areas of the habitat have been converted for alternative land uses which is a threat to pastoralism. Schwartz (2005) also reported that the increase in alternative land uses in the County has aggravated environmental degradation. Birch and Grahn (2007) reported that alternative land uses have created discord, promoted exclusivity and as such, increased production risks on pastoral livelihood system. The emerging scenario and the growth of private land ownership is a disjuncture from nomadic pastoralism that is traditionally associated with this region. As such, the Maasai pastoralists have ended up with multiple production risks. Moreover, their efforts to offset the water and pasture deficits have been frustrated since the vast open space, in which their livestock used to graze freely under communal trust, has been rendered unattainable.

The Land Use and Land Cover mappings covering 1987, 2000 and 2015 highlighted key land classification clusters in Kajiado County namely: built-up area, bare area, cropland, forestland, shrubland, grassland, riverine, wetland and waterbody. The heterogeneous nature of this landscape makes it suitable for the Maasai pastoralists to realise livestock mix strategy as browsers and grazers utilise different vegetation. This observation is similar to that of Niamir -Fuller (1999) who reported that the area has vast biodiversity. Gunderson and Holling (2002) and Homewood *et al.* (2009) reported that the area is endowed with vast species (both fauna and flora) intertwined with unique landscapes and sites for tourist attraction. Additionally, they reported that the co-existence of wild herbivores in non-protected areas is attributed to palatable grass species associated with nomadic pastoralism. Similarly, Homewood and Rodgers (1991) and Mutangah (2015) reported that wild herbivores were exhibiting a high level of spatial overlaps with domestic animals. Therefore, it is important to note that the unique natural assets, rich biodiversity and assemblage of wild herbivores, which also attracts revenue, complement income from pastoralism albeit indirectly as tourism ventures extend their goodwill by helping the conservation efforts of the Maasai pastoralists (Burnsilver *et al.*, 2003).

The Land Use and Land Cover mapping indicated that the forestland had increased progressively. As stated earlier, the Maasai community has a strong conservation value especially when it comes to the conservation of indigenous tree species such as *Juniperus procera*, *Olea europaea* and *Cuspidatus spp.* which are conspicuous in the area. It is important to note that these trees have accrued benefits which includes provision of herbal medicines, treatment extracts and other unique spices (Nahlik *et al.*, 2012).

The Land Use and Land Cover mapping indicated growth in alternative land uses such as built-up areas, cropland and bare areas. This observation is in agreement with that of Lalisa (2015) who noted the expansion of alternative land uses in the pastoral areas which included resettlement and cropland. According to Catley *et al.* (2013), improper land use is a threat to pastoral Social-Ecological System since they have adverse impacts to dryland ecosystem such as; shrinking grazing space, land fragmentation and exclusivity in land use. The finding also noted that the riverine, wetland and waterbody had declined at a faster rate as compared to what had been assumed earlier on. The riverine, wetland and waterbody areas are critical for dry season grazing, therefore, their drastic decline has an adverse impact on livestock rearing. This observation is similar to that of Galvin *et al.* (2004) who noted increased encroachment in riparian areas which he attributed to irrigated agriculture and preference for resettlement close to water resources. Therefore, these emerging land uses have increased water demands in an area that is already faced with water scarcity which is characterised by receding surface water. The receding surface water is demonstrated in the findings of the “Land Use and Land Cover” mappings.

There was considerable degradation in the Maasai pastoral Social-Ecological System which constrained the available pasture and had a negative effect on livestock production. Wasonga (2009); Munyasi *et al.* (2012) and Koech (2014) reported degradation and low natural vegetation cover in some parts of Kajiado County. Kidake *et al.* (2016) and Josten *et al.* (2014) also noted the extended bare areas and proliferation by invasive species. In as much as grassland areas appeared to have increased from the “Land Use and Land Cover” mappings, it is imperative to note that those areas were interpolated with invasive species whose segregation was impossible yet they are known to suppress the indigenous and palatable grass species. Therefore, with such a dynamic connection, it is almost impossible to ascertain whether the pasture is adequate or not. This observation is similar to that of Kidake *et al.* (2015) who reported that there is a significant spread

of invasive species of up to 60-80 per cent in the grass pasture fields in Kajiado County. Such ecological conversion is associated with loss of a significant portion of grazing areas in favour of the invasive species which poses a risk to the sustainability of their main livelihood system.

The sustainability component of pastoralism is pegged on the availability of natural resources. In this context, the degraded landscapes and the indeterminate status of invasive species could make the food insecurity situation in the area even worse considering that the Maasai pastoralists have limited adaptation options at their disposal. Bobadoye *et al.* (2016) noted that the limited access to critical resources by the Maasai pastoralists pose a threat to their sustainability. Therefore, at such times of scarcity, stewardship structures are adversely influenced and they become less cohesive leading to the adoption of other forms of lifestyle such as land alienation and sedentary lifestyle. Filho *et al.* (2017) opine that changes in lifestyle by a section of the community is linked to distortion of norms and social networks which threatens the sustainability of pastoral livelihood system. These sentiments concur with Kramer and Brewer's (1984) economic theory which states that "*where there is high competition for resources, social nonconformity dominates*".

## **5.7 Conclusion**

The study noted that the deliberate actions taken by the Maasai pastoralists to safeguard their habitat were bearing fruits. However, they have been misunderstood by outsiders who argue from the point of unknown. The outsiders view pastoral livelihood as backward and environmentally destructive yet the Maasai community have somehow managed to maintain their unique habitat with exceptional phenomena such as rich biodiversity and assemblage of wild herbivores. Nevertheless, the push for a sedentary agrarian-driven system is so strong despite it lacking the sustainability component which can compromise their pastoral Social-Ecological System. Alternative land uses which are incompatible to the pastoral livelihood system have worsened competition and rivalry as most of the resources are transboundary. The natural resources are shrinking as the invasive species dominates which has left the community to be increasingly vulnerable. It is against this backdrop that cultural practices have been recognized as a prudent pathway for sustainable pastoralism. The next chapter gives insight on the adaptation options which could enhance the pastoral livelihood system despite the changing climate and land use transformation.

## CHAPTER SIX

### CLIMATE CHANGE AND LAND TRANSFORMATION: ADAPTATION STRATEGIES TO ENHANCE LIVELIHOOD AND PASTORAL SOCIAL-ECOLOGICAL SYSTEM

#### 6.1 Introduction

This chapter presents results on the people's responses from the household surveys and triangulates them with the data and information from the Key Informant Interviews and Focus Group Discussions on adaptation strategies to enhance livelihoods and pastoral Social-Ecological System under climate change and land transformation.

#### 6.2 Adaptation Strategies

This section shows how the Maasai pastoralists responded to the household surveys and triangulated them with the data and information on adaptation strategies from Key Informant Interviews and Focus Group Discussions on measures which could enhance pastoral livelihood. Table 6.1 shows a summary of the feedback on the responses obtained.

The results indicate that the Maasai pastoralists rely on food and nutritional programmes at a score of 0.76 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 32 per cent (62), satisfied; 38 per cent (74), neutral; 12 per cent (23), less extent; 10 per cent (20) and dissatisfied; 8 per cent (16). This implies that the majority of the pastoralists were aware of the rising demand of food ratios from government and development partners to fill in the gaps of the food insecurity situation in the area. This observation was reaffirmed in the Focus Group Discussions (2016) which reported that *“the locals were slowly becoming more dependent on food ratios as a result of declining production due to drought in the area”*. Similarly, a Key Informant Interviewee (2016) reported that *“there are increased cases of malnourishment among women, children and elderly who are less mobile”*.

The results indicate low cash inflows in the form of remittances from friends, relatives or government at an average score of -0.66 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 11 per cent (21), satisfied; 8 per cent (16), neutral; 18



per cent (35), less extent; 30 per cent (59) and dissatisfied; 33 per cent (64). This implies that the majority of the pastoralists were aware of the low cash inflow. This observation was reaffirmed in the Focus Groups Discussion (2016) which reported that “*money circulation in the area was low rendering most of them to have weak purchasing power and therefore they cannot pay for alternative foodstuffs (grains)*”. Similarly, a Key Informant Interviewee (2016) reported that “*low liquidity levels were linked to limited access to cash or credits transfers*”.

The results indicate that the Maasai pastoralists were opting for employment at an average score of 0.20 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 23 per cent (45), satisfied; 23 per cent (45), neutral 21 per cent (41), less extent; 17 per cent (33) and dissatisfied; 16 per cent (31). This implies that the majority of the pastoralists were aware of alternative opportunities and affirmed their willingness for engagement in non-pastoral ventures. This was reaffirmed during the Focus Groups Discussions (2016) where it was reported that “*their educated youths have opted for non-pastoral alternatives which are less sensitive to climate shifts*”.

The results indicate that the Maasai pastoralists are adopting handcraft at an average score of 0.53 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 27 per cent (53), satisfied; 29 per cent (57), neutral; 22 per cent (43), less extent; 12 per cent (23) and dissatisfied; 10 per cent (19). This implies that the majority of the pastoralists were aware that the artefacts and decorations could earn them extra income to complement pastoralism. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported that “*the locals had morphed handcraft from cultural activities to serious business enterprises where extra income could be generated*”.

The results show that the Maasai pastoralists have embraced beekeeping at an average score on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 30 per cent (59), satisfied; 29 per cent (57), neutral 18 per cent (35), less extent; 11 per cent (21) and dissatisfied; 12 per cent (23). This implies that the majority of the pastoralists were involved in beekeeping as a way of generating extra income. This observation was reaffirmed in the Focus Group Discussions (2016) where it was reported that “*the locals were actively involved in beekeeping for honey production. Similarly, a Key Informant Interviewee (2016) reported that “there was increased production of honey in the area and they were seeking a new market*”.

The results indicate that the Maasai pastoralists had involved livestock insurance cover at an average score of 0.11 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 21 per cent (41), satisfied; 18 per cent (35), neutral; 29 per cent (57), less extent; 16 per cent (31) and dissatisfied; 16 per cent (31). This implies that the majority of the pastoralists were aware and affirmed their readiness to take up livestock insurance cover as a mitigating measure against climate risks. This observation was reaffirmed by a Key Informant Interviewee (2016) who reported that “*some sections are covered by a regional-specific index-based livestock insurance where pay-outs of up to 80 per cent of the losses are compensated if the losses are attributed to droughts*”. Similarly, in the Focus Group Discussions (2016) it was reported that “*the locals were willing to take up livestock insurance once they are enlightened about it*”.

The results indicate that the Maasai pastoralists incorporated partnership in governance and management of key natural resources with an average score of 0.39 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 30 per cent (59), satisfied; 29 per cent (57), neutral 18 per cent (35), less extent; 11 per cent (21) and dissatisfied; 12 per cent (23). This implies that the majority of the pastoralists were aware and affirmed the critical role of collaboration with other stakeholders in the governance and management of key natural resources. This observation was reaffirmed by the Focus Group Discussions (2016) which reported that “*their governance supported networks was composed of influential individuals, village elders, religious leaders and government representatives who came together to ensure that the common interest supersedes individual interest on matters to do with natural resources*” Similarly, a Key Informant Interviewee (2016) reported that “*there is cohesiveness in the leadership structures and this has enabled the community reach amicable consensus on utilisation of transboundary resources while maintaining our dynamics ecosystem*”.

The results indicate capacity support initiatives at an average score of 0.65 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 31 per cent (60), satisfied; 29 per cent (57), neutral 22 per cent (43), less extent; 10 per cent (19) and dissatisfied; 8 per cent (16). This implies that the majority of the pastoralists were aware and affirmed their appreciation for initiatives aimed at improving their levels of preparedness to natural hazards. This observation was reaffirmed in the Focus Group Discussions (2016) which reported that “*training*”

*has enabled them to have a change in mind-set and as a result, the community is ready to face risks and uncertainties*". Similarly, a Key Informant Interviewee (2016) reported that *"the community is a beneficiary of trainings funded by both the government, development and private partners with the intent to enhance their capacity meet their basic needs"*

The results show that the Maasai community were embracing peace enhancement programmes at an average score of 0.60 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 29 per cent (57), satisfied; 32 per cent (62), neutral; 18 per cent (32), less extent; 12 per cent (23) and dissatisfied; 9 per cent (18). This implies that the majority of the pastoralists had encountered conflicts and they were appreciating the roles conflict resolution programmes played in the area. This observation was reaffirmed in the Focus Group Discussions (2016) which reported that *"the root causes of conflicts and rivalry in this County are attributed to the transboundary natural resources in the area"*. Similarly, a Key Informant Interviewee (2016) reported that *"there are several peace programmes undertaken by both the government, development and private partners in the area"*.

The results demonstrate that the Maasai pastoralists have embraced livestock mix at an average score of 0.57 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 30 per cent (59), satisfied; 33 per cent (64), neutral; 11 per cent (21), less extent; 17 per cent (33) and dissatisfied; 9 per cent (18). This implies that the majority of the pastoralists were aware and affirmed preference of livestock mix which included goats, sheep and camels in their herds with the intention of reducing production risks. This observation was reaffirmed in the Focus Group Discussions (2016) which reported that *"this move has been necessitated as an intervention against harsh climate conditions. We realised that the grazers and browsers have different feeding habits and have varying tolerance levels to drought situations"*. Similarly, a Key Informant Interviewee (2016) reported that *"the locals are opting to diversify their herds to reduce risks attributed to the extreme climatic conditions in the area"*.

The results demonstrate that the Maasai pastoralists have embraced structured markets at an average score of 0.59 on a survey scale of perception. The Likert scale was distributed as follows; extremely satisfied; 29 per cent (56), satisfied; 27 per cent (53), neutral 23 per cent (45), less extent; 13 per cent (25) and dissatisfied; 8 per cent (16). This implies that the majority of the pastoralists were aware and affirmed the importance of robust business enterprises. This was

reaffirmed in the Focus Group Discussion (2016) which reported that “markets in the area have morphed from cultural activities where their livestock could hardly fetch fair market prices into business enterprises with various merchandise”. Similarly, a Key Informant Interviewee (2016) reported that “the community has expanded their artefacts production for alternative markets in the diaspora through the support of private and development partners”.

**Table 6.1:** Adaptation strategies to enhance pastoral livelihood

Adaptations	Respondents (N=195)					Avg. Score
	Extremely satisfied (+2)	Satisfied (+1)	Neutral (0)	Less extent (-1)	Dissatisfied (-2)	
Food aid	62	74	23	20	16	0.76
Remittances	21	16	35	59	64	-0.66
Employment	45	45	41	33	31	0.20
Handcraft	53	57	43	23	19	0.53
Beekeeping	37	45	49	39	25	0.16
Insurance	41	35	57	31	31	0.11
Partnerships	53	57	27	31	27	0.39
Capacity support	60	57	43	19	16	0.65
Peace initiatives	57	62	35	23	18	0.60
Livestock mix	59	64	21	33	18	0.57
Structured markets	56	53	45	25	16	0.59

**Explanation:** Perception survey scale on attitude is awarded or affirmed when the mean score  $>0$ ; weak or dissatisfied when the mean score  $<0$

**Data source:** Author’s survey, 2016

Additionally, Chi-Square statistics were computed in various segments to examine the dependence and relationship between various groups of variables as shown in Table.6.2.

The  $\chi^2$  computed (222.236) is greater than  $\chi^2$  critical (26.509). Therefore, the null hypothesis that “association of pastoralists’ resilience are independent of specific adaptation variables” is rejected. It is, therefore, conceivable that the Maasai pastoralists’ capability to cope with the adverse impacts of climate change coupled with land use transformation is informed by their ability to implement desired changes in their habitat. This might be attributed to the evolving cultural practices despite the underlying issues which have negatively affected pastoral livelihood system.

**Table 6.2:** *Pastoralists ability on selected intervention on enhancing pastoral resilience*

Adaptations variables indicators	Chi-Square calculations					
	ES	S	N	LE	D	(O - E) <sup>2</sup> /E
Food aid	3.449	10.373	5.921	3.903	3.846	17.245
Remittances	16.000	24.020	0.237	25.290	55.538	121.085
Employment	0.326	0.706	0.237	0.129	0.962	2.36
Handcraft	0.326	0.706	0.658	2.065	3.846	7.601
Bee Keeping	2.939	0.706	3.184	2.065	0.038	8.932
Insurance	1.306	5.020	9.500	0.000	0.962	16.788
Partnerships	0.326	0.706	3.184	0.000	0.038	4.254
Capacity support	2.469	0.706	0.658	4.645	3.846	12.324
Peace initiatives	1.306	2.373	0.237	2.065	2.462	8.443
Livestock mix	2.041	3.314	7.605	0.129	2.462	15.551
Structured markets	1.000	0.078	1.289	1.440	3.846	7.653
$\chi^2$						222.236

**Data source:** Author’s survey, 2016

**Key:** ES = Extremely satisfied; S = Satisfied; N = Neutral; LE = Less extent; D = Dissatisfied;  $\chi^2$ = Chi-Square

Provided that the level of significance  $\alpha = 5\%$  while the degree of freedom - 40 = df

### 6.3 Risks and Opportunities in Adaptation Interventions

The results reveal highlights of key interactions between the pastoralists' responses and their Social-Ecological System on the selected adaptation strategies. These were rated in terms of the Maasai community' desires to sustain their livelihood, potential risks and profound barriers on implementation of adaptation interventions. Table 6.3 shows the patterns which culminate from the thematic analysis.

**Table 6.3:** *Risks and opportunities on implementation of adaptation interventions*

Opportunities	Implementation	Risks	Rank
Regional index-based livestock insurance	Payments (partly by government and self), policy interventions and compensation/ pay-out	Reluctance to take insurance cover, limited accurate data, high premiums and delays in pay-out	9
Employment in the hospitality sector	Policy intervention by ensuring inclusivity in recruitment of guides, wardens and drivers	Low levels of education	8
Diversify on non-pastoral livelihood options	Beekeeping, bead making, charcoal production	Illegal logging, selling off of land and land degradation	6
Structured markets	Linkages with other markets to reduced travel time and reasonable prices	Inadequate markets, lack of price standardization and low purchasing power	4
Livestock mix	Strategic grazing and ensuring that no one disease eliminates the entire herds	Field sizes are getting smaller, overgrazing and low compliance levels	5

Capacity support	Monetary incentives, access to credit, radio, television, phones and other appropriate technologies	Low education levels, inadequate extension services, high poverty levels	2
Food aid	Strategic food reserves from the government, donations and other emergency assistance from NGOs	Delay in response, a sharp rise in food prices, rapidly growing population and recurrent droughts causing chronic food insecurity	1
Partnerships	Building strong social networks to access wider pastoral living space	Incompatible land-use systems, unclear demarcations on transboundary resources and weak legal systems	7
Peace initiatives	Collaborative governance and policy intervention	Rivalry, conflicts and cultural practices such as cattle rustling	3
Remittances	Increase cash inflow through cash transfers from social protection and off-take programmes, cash inflow from relative or friends from domestic and diaspora	Irregular payments, limited accurate data, financial/economic recession	10

**Data source:** Author's survey, 2016

## 6.4 Discussions

The Maasai community still tried to maintain livestock rearing which is attributed to its obligatory roles in the Maasai cultural context where the settlement of fines and dowry payments cannot be completed without the involvement of an animal. This is in line with the findings of OleSaitabau (2014) who noted a strong cultural attachment to animals. The study established that the Maasai pastoralists were embracing new ideas in their economic activities. The results indicated that the Maasai pastoralists were transitioning to mixed livelihood, insuring their livestock, taking up employment and adopting livestock mix. This change of mind-set has come about due to realisation that relying on livestock production for survival as a single economic activity is exposing them to poverty and rendering them to be reliant on food aid.

Depletion of resources including water and pasture has prompted various inventions to enhance the community's resilience. According to FAO (2016), understanding how households cope with the risks posed by climate change and its impacts is important towards building their resilience. Therefore, the Government, through its various agencies, has been involved in the coordination, joint utilisation and management of key natural resources in the County (Shiferaw *et al.*, 2017). The measures put in place by the Government are key for the successful conservation of the pastoral Social-Ecological System where livelihoods are nature-based. To complement the Government's efforts, the Maasai pastoralists have made frantic efforts to sustain cohesiveness in the management of key natural resources in the County. This cooperation structure works towards the attainment of the common good through amicable consensus. Sharma *et al.* (2014) and Shiferaw *et al.* (2017) noted that the Maasai community has high regard for authority. Sharma *et al.* (2014) further praised their customary laws for they ensured that there was proper management of natural resources. Mwangi and Dohrn (2006) noted that the Maasai Community livelihood is anchored on conservation as a core pillar. Similar sentiments were resonated by Ocholla *et al.* (2016) and Duit *et al.* (2009) who reported that there were deliberate actions by the Maasai community to conserve the environment and that they passed those actions to the new generations.

The sustained conservation measures are a key pillar in their indigenous governance structure. Homewood and Rodgers (1991) and OleSaitabou (2014) opine that their strict adherence to cultural practices contributed to the well-built ecology as their livestock production system is accompanied by collective actions and co-existence which are harmonious with nature. Sharma *et*



*al.* (2014) and Ocholla *et al.* (2016) noted a strong commitment among the Maasai peers in upholding customary rights which has enabled them to maintain zoning. Zoning has enabled them to preserve certain areas for wet (the plains areas) or even dry season grazing (the forestland). However, field sizes are getting smaller since substantial portions of land have been sold to private land holders who are non-indigenous and do not understand how the Maasai graze their livestock. Privatisation has, therefore, threatened communal land management and the Maasai pastoralists.

In as much as the area is experiencing shifting climatic patterns and land transformation, traditional seasonal movement of livestock has persisted. Challinor *et al.* (2009); Nyariki *et al.* (2009) and Thornton *et al.* (2011) also made the same observation and reported that the community has continued to rely on seasons for livestock production. Malo *et al.* (2011) reported that the shifting climatic patterns could have an adverse impact on the community's coping strategies. Similar sentiments were resonated by IOM (2010) Report which mentioned that the Maasai community is now in need of humanitarian assistance due to the adverse effects of climate change. In addition, mobility, an important adaptation strategy used by the Maasai pastoralists to access pasture and water across the vast dryland ecosystem, has been curtailed due to change in land-use patterns. This has left the Maasai community with limited adaptation options. Similar sentiments were resonated by Cooper *et al.* (2008); Kirimi *et al.* (2013); Pal and Eltahir (2015) and WHO (2014) who reported increased multiple production risks in Kajiado County due to land-use change.

As much as the Maasai community has made frantic efforts in an attempt to cope with the changes in climate trend and land transformation, its response has not adequately addressed the problem. The study, in a participatory manner, identified possible intervention measures such as food aid, remittances, employment, handcraft, beekeeping, insurance, partnerships, capacity support, peace initiatives, livestock mix and structured markets which could be used to assist the Maasai community sustain pastoralism that is currently under threat. The FGDs indicated that food aid was the most popular while remittances was the least popular though they are both not sustainable. The other adaptation interventions which included structured markets, livestock mix, mixed livelihood, employment and livestock insurance were considered as the most effective. Lastly, it clearly emerged that capacity support, peace initiatives and partnerships were the measures that needed to be sustained in the long term as effective adaptation strategies to climate change. The finding noted that the Maasai community is currently embracing livestock mix which is a shift

from their norm. Previously, they would mostly rear cattle but they have now started rearing goats, sheep and have even embraced camels. This finding is similar to that of Illius and Gordon (1992); Nassef *et al.* (2009) and Kihila (2015) who noted that there was evidence of an exponential increase in goats and sheep in comparison to cattle in the area which was attributed to their high levels of tolerance. Diversification of livestock breeds is a measure to effectively utilise the different forms of vegetation that exists in their heterogeneous landscape because the grazers and browsers feed on different plant species. This observation is in line with that of Carpenter *et al.* (2010) who noted the importance of livestock diversification in reducing production risks.

Additionally, the study noted that the local markets in Kajiado County had morphed from selling traditional products such as animals to modern markets that had various merchandise for sale. The Maasai pastoralists achieved the changes with the support of the Government and development partners who upgraded the infrastructure and social amenities, and as such, made significant improvement on key market centres to entice the community to the alternative investments albeit with trade-offs from nomadic pastoralism. Similarly, Ellis (2000) noted that the area was opening up due to the growth of alternative investments that enabled the locals to generate extra income thus enhancing their resilience levels.

Furthermore, the study noted that the Maasai community is currently embracing alternative sources of income which are non-pastoral namely; handcraft, beekeeping and employment due to the threat posed to pastoralism by climate change. It is imperative to note that both formal and informal employment has attracted many locals. The ones who have formal education prefer to be engaged in alternative opportunities within the County or in the diaspora. Similarly, Ranganathan *et al.* (2018) and Titonell *et al.* (2011) reported that employment has exposed the community members to a point where they have now embraced alternative sources of livelihood. As such, they have had alternative sources of extra cash inflow which has enhanced their resilience to climate-related risks (Smiley, 2016).

The findings also noted that there were auxiliary structures in the County such as capacity building, partnerships among the various leadership structures and conflict resolution initiatives whose main intention is to enhance the locals' resilience to the impacts of climate change. Additionally, index-based livestock insurance, though a new concept and a mitigation choice, made it easy for the Maasai community to get external support when natural disaster strikes and that has helped them

sustain their pastoral way of life. OleSaitabou (2014) emphasised the need of enhancing capacities among the pastoralists communities in the ASALs and similar sentiments were resonated by Little *et al.* (2001) who argued that peace is integral for the sustainable livestock production system.

## **6.5 Conclusion**

The Maasai pastoralists depend on natural systems which are currently dwindling against the backdrop of limited adaptation options. Indeed, their response processes have been inadequate compared to the hurdles which are attributed to shifting climatic patterns and land transformation. In a bid to enhance their resilience, the study, through a participatory manner, noted intervention measures such as the distribution of food aid, remittance from their relatives in the form of cash inflows from within and diaspora, livestock insurance covers, partnerships and collaborative governance structures, conflict resolution initiatives and capacity building. The other alternatives undertaken are livestock mix, sale of artefacts, beekeeping, employment opportunities in other sectors and establishment of structured markets where other forms of merchandise other than livestock are traded as well. The next chapter entails the conclusion and the recommendations.

## CHAPTER SEVEN

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 7.1 Summary

The historical climate trend analysis showed decrease in annual average rainfall, reduction in rainfall in the MAM season and a general rise in temperatures. These are expected to exacerbate the harsh conditions in this region since majority of the Maasai pastoralists' dependency on climate-sensitive forage from natural systems for livestock production. The evaluation of the pastoral Social-Ecological System did show changes in the various Land Use and Land Cover classes with depletion of pastures and water sources. This has created new risks for the local Maasai pastoralists who depend on natural resources for livestock production. The adaptation strategies used by the Maasai pastoralists took into cognisance the pertinent issues around their capabilities. These strategies includes their high levels of resilience despite the risks facing their main livelihood as the natural resources which they are dependent on dwindle. More so, the Maasai pastoralists have continue sustain livestock rearing embedded in a blend on both the traditional and the emerging adaptation strategies.

#### 7.2 Conclusion

The pastoralism livelihood system practised by the Maasai community in Kajiado County is highly rain-fed. It is in this regard that they will continue to face the adverse impacts of the rapidly shifting climate patterns on their pastoral Social-Ecological System. The study established a decline in the annual average rainfall trend and unreliability of seasonal patterns which were compounded with rising temperatures (both the  $T_{\max}$  and  $T_{\min}$ ). The shift in climatic patterns was compounded with land-use transformation with a reduction in some of the critical biophysical features that the Maasai pastoralists have all along relied on for sustenance. The built-up area, bare area, cropland, forested land, riverine, grassland, shrubland, wetland and waterbody had undergone substantial changes in their respective acreage. The transformations did not augur well with the Maasai pastoralists' mobility needs. Indeed, there is increased pressure on the critical resources such as water whose utility in crop production have increased two-fold yet the rain, which recharges surface water, is on a declining trend. Additionally, the invasive species have spread into significant areas of the grassland, and as such, they have suppressed indigenous and palatable

pastures. Therefore, it has now come to the realisation of the Maasai community that livestock rearing, which they highly regard, needs to be complemented with non-pastoral livelihood activities. The findings established that in their pursuit for survival, the Maasai Community have adopted suitable adaptation options such as beekeeping for honey production, employment in other sectors and linkages with markets where livestock as well as other forms of merchandise, are traded as measures to reduce their dependence on nature-based resources. Besides, the study also established that the government, private and development partners have used index-based insurance cover, infrastructure, peace, security and capacity enhancement programmes to enhance pastoral livelihood resilience in the area. However, these interventions have to be implemented in a manner that is acceptable by the Maasai community.

### **7.3 Recommendations**

Dryland ecosystems are under socio-economic pressure that, if not well managed, poses a serious threat of further land degradation with possibly irreversible consequences. It is in this regard that the study advocates for well-coordinated structures as well as coherent and effective strategies to respond to the shifts in climate patterns in dryland ecosystems. To this end, this study proposes the following recommendations:

- There is a need to recognize the local community and their social setting for effective planning to achieve stability and sustainability in the dryland ecology
- There is a need for accurate and updated climate information to aid in the prediction of early warning against weather extremes in the dryland ecosystems.
- There is a need for periodic mapping of the natural resource base to avert ecological stress in the dryland ecosystem.
- There is a need for improved land adjudication with more community involvement especially on transboundary resources to minimise rivalry in land use.

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## APPENDICES

### Appendix 1. Consent Form

Hello Sir/Madam,

My name is James Kaoga, I am a graduate student of University of Nairobi doing my research in your County. The research aims to enhance the resilience of the natives through the integration of social-ecological system variables into adaptation strategies in the face of a climate shift. To meet this objective, it is important to obtain information from the residents such as you. Remember, this information is strictly confidential and for academic purposes only. Thus, there are no personal benefits or risks in your participation. For more information about this study, please kindly contact the Institute for Climate Change and Adaptation on this email: [icca.uonbi.ac.ke](mailto:icca.uonbi.ac.ke).

May I have your permission to undertake this interview?

Yes  (proceed with interview)

No  (thank the person and look for the next respondent).

**NB/ The overall understanding of climate change was presented to your audience before the interview.**





**Section B: Historical Climate Trend and its Impacts on Pastoral Livelihoods**

104 Have these socio-economic activities been impacted by the shifts in climate patterns in Kajiado County?

1) <b>Loss in livestock live weight</b>	1	2	3	4	5
2) <b>Decline in herd sizes</b>	1	2	3	4	5
3) <b>Pasture loss</b>	1	2	3	4	5
4) <b>Increase in livestock diseases</b>	1	2	3	4	5
5) <b>Interrupted grazing cycle</b>	1	2	3	4	5
6) <b>Distorted cultural rites</b>	1	2	3	4	5
7) <b>Unstructured markets</b>	1	2	3	4	5
8) <b>Dissolution of engagements</b>	1	2	3	4	5

**Key:**

**1 = Very great**

**2 = Great**

**3 = Neutral**

**4 = Lesser**

**5 = None at all**

**Section C: Evaluation of Pastoral Social-Ecological System and its Influence on Pastoralists Livelihood.**

105 Have these land use transformation influenced the sustainability of pastoral livelihoods in Kajiado County?

<b>1) Water body</b>	1	2	3	4	5
<b>2) Conservancies</b>	1	2	3	4	5
<b>3) Crop farming</b>	1	2	3	4	5
<b>4) National parks</b>	1	2	3	4	5
<b>5) Forest reserves</b>	1	2	3	4	5
<b>6) Urban centres</b>	1	2	3	4	5

**Key:**

**1 = Very great**

**2 = Great**

**3 = Neutral**

**4 = Lesser**

**5 = None at all**

106 What are the impacts of LULC Changes on Pastoral Livelihood System?

<b>1) Transboundary resources</b>	1	2	3	4	5
<b>2) Water resources</b>	1	2	3	4	5
<b>3) Enclosures</b>	1	2	3	4	5
<b>4) Resettlement</b>	1	2	3	4	5
<b>5) Invasive species</b>	1	2	3	4	5

**Key:**

**1 = Very great**

**2 = Great**

**3 = Neutral**

**4 = Lesser**

**5 = None at all**

**Section C: Determination of Adaptation Strategies to Enhance Resilience of the Pastoral Social-Ecological System.**

107 The climate change and land use transformation have weakened pastoralism to the point of rendering it unsustainable. Based on these adaptation strategies, rate these applicable interventions in enhancing resilience Kajiado County.

<b>1) Food aid</b>	1	2	3	4	5
<b>2) Remittances</b>	1	2	3	4	5
<b>3) Employment</b>	1	2	3	4	5
<b>4) Handcraft</b>	1	2	3	4	5
<b>5) Beekeeping</b>	1	2	3	4	5
<b>6) Insurance</b>	1	2	3	4	5
<b>7) Partnerships</b>	1	2	3	4	5
<b>8) Capacity support</b>	1	2	3	4	5
<b>9) Peace initiatives</b>	1	2	3	4	5
<b>10) Livestock mix</b>	1	2	3	4	5
<b>11) Structured markets</b>	1	2	3	4	5

**Key:**

**1 = Extremely satisfied 2 = Satisfied 3 = Neutral 4 = Less extent 5 = Dissatisfied**

### **Appendix 3. Focus Group Discussions schedule**

#### **Section A: Historical Climate Trend and its Impacts on Pastoral Livelihoods**

- (i) How often do you experience hot nights?
- (ii) How often do you experience failed rain seasons?
- (iii) Have there been changes in precipitation patterns for the past 30 years?
- (iv) If yes, have these climatic changes affected the pastoral livelihood?

#### **Section B: Evaluation of Pastoral Social-Ecological System and its Influence on Pastoralists Livelihood.**

- (i) How was the previous traditional migration?
- (ii) Are there any emerging migration trends contrary to what was experienced in the past: distance trekked during migration? :(a) same (b)doubled (c)tripled
- (iii) How have the food production levels been affected: milk and meat?
- (iv) What do you think of the alternative land uses such as irrigated agriculture?
- (v) Do you sometimes seek refuge out of our County?

#### **Section C: Determination of Adaptation Strategies to Enhance Resilience of the Pastoral Social-Ecological System.**

- (i) Have you received assistance from any quarter either in cash, food or in-kind; if yes state the source of aid?
- (ii) Identify some of the suitable adaptation measures that still apply in your locality?
- (iii) Based on the adaptation measures listed above, kindly rank the strategies in order of preference?
- (iv) Describe your experience of migration patterns in terms of the duration of migration? (a) short term-3 month (b)long term- 1 year (c) recurrent- back and forth)

## **Appendix 4. Key Informant Interview schedule**

### **Section A: Historical Climate Trend and its Impacts on Pastoral Livelihoods**

- (i) What is the general understanding of climate change among the populace of this County?
- (ii) Could you comment on the historical account of the demographic trends and resource-base in this County?
- (iii) What are the emerging migration patterns in this County?
- (iv) State some of the Adaptation strategies utilised in this County?
- (v) Of the adaptation strategies stated, which ones have been successful or otherwise?
- (vi) Is there an observed trend in the manner in which this particular option had been upheld in this County?
- (vii) In your view, is there a relationship between climate change and pastoral livelihood system Please comment on your response?

### **Section B: Evaluation of Pastoral Social-Ecological System and its Influence on Pastoralists Livelihood.**

- (i) What are the natural resource-based challenges experienced in this county based on the population growth?
- (ii) Briefly highlight the impact of climate change on the livelihoods of residents of this County
- (iii) Who are the most affected during droughts and what makes them the most vulnerable
- (iv) What are the risks as the pastoralists to the alternative land uses which rivals pasture space?
- (v) Is there any policy to address the weak land tenure systems in this county? (comments on efficacy)
- (vi) In your assessment is the government involvement satisfactory?
- (vii) Are the locals involved in dealing with the land issues?

**Section C: Determination of Adaptation Strategies to Enhance Resilience of the Pastoral Social-Ecological System.**

- (i) What are the key triggers of government interventions?
- (ii) How are the migrant's needs addressed-on transit and upon settlement?
- (iii) What are the adaptation mechanisms of the migrants and are they sustainable for their livelihoods?
- (iv) Please comment on the efficacy of the adaptation methods adopted by the pastoralists?
- (v) What are some of the long-lasting strategies that could be applied to improve adaptability and sustainability over time?
- (vi) What Coping mechanisms have been devised to enhance livelihood despite the declining natural resources, namely: water, pasture or land?
- (vii) What are the existing initiatives in the county to fill the gaps of food insecurity?
- (viii) Which traditional activities have been maintained to deal with the limitation
- (ix) Who are the key parties involved in humanitarian aid (clansmen, government, aliens)?
- (x) Identify stakeholders on the periphery who need to be more involved
- (xi) Who is responsible for the implementation of peace initiatives?



**Appendix 5. Summary Internal Validation for the LULC**

<b>Class Name</b>	<b>Reference Totals</b>	<b>Classified Totals</b>	<b>Number Correct</b>	<b>Producers Accuracy</b>	<b>Users Accuracy</b>
Forestland	24	16	9	37.50%	<b>56.25%</b>
Shrubland	214	198	181	84.58%	<b>91.41%</b>
Grassland	13	37	10	76.92%	<b>27.03%</b>
Cropland	3	3	3	100.00%	<b>100.00%</b>
Wetland	2	2	2	100.00%	<b>100.00%</b>
Built area	1	1	1	100.00%	<b>100.00%</b>
Overall classification accuracy = 80.16%					

Appendix 5 shows accuracy which was utilised and it gives an indication of the quality of map based on areas of interest. The overall accuracy is essential as it tells us the proportions that are correctly mapped out of the reference sites which are expressed in percentages. In this regard, the study has attained an accuracy level of 80.16% with 100 % accuracy being a perfect classification.

## Appendix 6. Research Permit



### NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,  
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9<sup>th</sup> Floor, Utalii House  
Uthuru Highway  
P.O. Box 30623-00100  
NAIROBI-KENYA

Ref No.

Date:

29<sup>th</sup> October, 2015

NACOSTI/P/15/4986/8428

James Otieno Kaoga  
University of Nairobi  
P.O. Box 30197-00100  
NAIROBI.

#### RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "*Climate change adaptation for the Maasai community in Kajiado County, Kenya - integrating biocultural diversity in pastoral system,*" I am pleased to inform you that you have been authorized to undertake research in **Kajiado County** for a period ending **29<sup>th</sup> October, 2016**.

You are advised to report to the **Chief Executive Officers of the selected Government Agencies, the County Commissioner and the County Director of Education, Kajiado County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

  
SAID HUSSEIN  
FOR: DIRECTOR GENERAL/CEO

Copy to:

The Chief Executive Officers  
Selected Government Agencies.

The County Commissioner  
Kajiado County.



*National Commission for Science, Technology and Innovation is ISO 9001:2008 Certified*

Appendix 7. Research Identification Tag

**THIS IS TO CERTIFY THAT:**  
**MR. JAMES OTIENO KAOGA**  
of **UNIVERSITY OF NAIROBI, 0-0**  
homabay, has been permitted to conduct  
research in **Kajiado County**

on the topic: **CLIMATE CHANGE  
ADAPTATION FOR THE MAASAI  
COMMUNITY IN KAJIADO COUNTY,  
KENYA - INTEGRATING BIOCULTURAL  
DIVERSITY IN PASTORAL SYSTEM.**

for the period ending:  
**29th October, 2016**

  
Applicant's  
**Signature**

  
Permit No : **NACOSTI/P/15/4986/8428**  
Date Of Issue : **29th October, 2015**  
Fee Received : **Ksh 2000**

**NACOSTI**  
National Commission for Science, Technology and Innovation  
**Director General for Science, Technology & Innovation**

# Appendix 8. Ant Plagiarism Report

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**CHAIRMAN**  
 DEPARTMENT OF EARTH & CLIMATE SCIENCES

03 AUG 2021

Sign: \_\_\_\_\_  
 FACULTY OF SCIENCE & TECHNOLOGY  
 UNIVERSITY OF NAIROBI