ASSESSMENT OF VULNERABILITIES TO DROUGHT, IMPACT AND ADAPTATION OPTIONS IN PASTORAL PRODUCTION SYSTEMS IN LAISAMIS, MARSABIT COUNTY, KENYA

BY

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DECLARATION

Declaration by student

I hereby declare that this is my original work; it has never been partially or wholly presented to any institution for the award of any degree to the best of my knowledge.

Signature…….....Date……..……

…

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DEDICATION

This thesis is dedicated to all the individuals who have committed their time and resources in ensuring sustainable use of the environment for the future generation. Remember, "We did not inherit the environment from our forefathers, but we borrowed it from our children" (a saying from the Red Indians of USA).

ABSTRACT

Drylands are home to about 25–30% of the global population, or around two billion people, 90% of those who live in developing countries. The same report indicates that 40% of the human population of both Africa and Asia live in such these areas. Drylands cover 80 % of Kenya's land surface in Kenya and 100% of the study area. Drought is a major disaster causing huge damages to humanity, the environment and the economy at global, continental, national and in the study area. Despite making considerable progress on monitoring, forecasting and mitigation of droughts across the world, there are still gaps in drought vulnerability assessment, determining drought impacts and adaptation options. The evidence of gaps is the too frequent and severe drought without adequate interventions. Therefore, the purpose of this study was to assess vulnerabilities to drought, impact and adaptation options of pastoralists production systems in Laisamis Sub-County, Marsabit County. The specific objectives of the study were to: Assess magnitude of vulnerabilities to drought in pastoral production system; assess the impact and find out the adaptation options to drought in pastoral production system. The study employed a crosssectional research design which was used to provide systematic and accurate facts about households, the community and describes current situation. Stratified random sampling approach was used to obtain the primary data. The minimum sample size of 376 households was calculated using Taro Yamane (1967:886) simplified formula. The study targeted 6,182 households in four locations in Laisamis Sub-County, Marsabit County, Kenya. The unit of analysis was the households heads which were interviewed. Secondary data were obtained from relevant public reports, agricultural reports, statistical abstracts and publications from development partners. The household Vulnerability Index was calculated using Principal Component Analysis (PCA).This was done by subtracting average adaptation indices and exposure and sensitivity indices. Primary data on drought adaptation options and impacts of drought were obtained through questionnaires. The study considered various biophysical and socio-economic factors to calculate Vulnerability Index. Weights for different indicators to calculate the Household Vulnerability Index (HVI) were used. Data analyses were done using frequencies, percentages, Pearson correlation coefficient, cross tabulations and Chi square tests. The presentations of results were done in form of narrative, graphs, tables, pie and bar charts. Household vulnerability was assessed in this study. The results show that 2.3 % of the households were highly vulnerable, 32.6 % were moderately vulnerable and 65.1 % less vulnerable. The overall drought vulnerability index for the study area was 0.46, indicating moderate vulnerability. Drought adaptation options options were identified. Drought impacts was measured through Drought Index indicating 53 % for the study area resulting in less available pasture, low livestock population, high livestock mortality, low meat and milk production. It can be concluded that understanding the vulnerability of households to drought is indispensable for decision-makers to device adaptation strategies for long-term resilience building of pastoral households. The study concluded minimum external interventions are required for resilience building in the study area.

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ACRONYMS AND ABBREVIATIONS

ACTED:	Agency for Technical Cooperation and Development
ASALs:	Arid and Semi-Arid Lands
CCAPS:	Climate Change and African Political Stability
CDCs:	Community Development Committees
CDKN:	Climate Development Knowledge Network
CTA:	Technical Centre for Agriculture and Rural Cooperation
CWCB:	Colorado Water Conservation Board
DMOs:	Drought Management Officers
DRR:	Disaster Risk Reduction
DSGs:	District Steering Groups
EWS:	Early Warning Systems
FBOs:	Faith Based Organisations
GHG:	Green-House Gases
GoK:	Government of Kenya
IDPs:	Internally Displaced Persons
IIRR:	International Institute of Rural Reconstruction
IPCC:	Inter-Governmental Panel on Climate Change
KFSSG:	Kenya Food Security Steering Group
MCIDP:	Marsabit County Integrated Development Plan
MDGs:	Millennium Development Goals
MODIS:	Moderate Resolution Imaging Spectroradiometer
NDMA:	National Drought Management Authority
NDMC:	National Drought Management Centre
NGOs:	Non-Governmental Organisations
ODI:	Overseas Development Institute
PDRA:	Participatory Disaster Risk Assessment
PICD:	Participatory Integrated Community Development
PRA:	Participatory Disaster Risk Reduction
SRA:	Strategy for Revitalisation of Agriculture
UNCCD:	United Nations Convention to Combat Desertification
UNDP:	United Nations Development Programme
UNEP:	United Nations Environment Programme
UNFCCC:	United Nations Framework Convention on Climate Change
USA:	United States of America
WMO:	World Meteorological Organisation.

WORKING DEFINITIONS OF TERMS

Adaptation

The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001).

Adaptive Capacity

"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 2001). The ability (or potential) of a system to successfully adjust to climate change (including climate variability and extremes) to (i) moderate potential damages, (ii) to take advantage of opportunities, and/or (iii) to cope with the consequences (IPCC, 2007).

In this study adaptive capacity refers to individual and collective strength and resources that can be enhanced, mobilised and accessed, to allow individuals and communities to shape their future by reducing disaster risk. This includes prevention, mitigation, and survivability of individuals and readiness of the community.

Agricultural drought

It occurs when soil moisture and rainfall are inadequate during the growing season to support healthy crop growth till maturity and cause decline in food grain production. It may also cause decline in fodder production from grazing lands, pastures and trees.

(IIRR, 2013):

Climate Change

A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (IPCC, 2007).

Climate Variability

Variations in the mean state and other statistics (standard deviation, statistics of extremes, etc) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) (IPCC, 2007).

Climate Change Vulnerability

The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007). Generally, refers to unsafe climatic conditions including physical, economic, social, political, environmental and Technical.

Disaster

Serious disruption of the functioning of a society causing widespread human, material or environmental losses, which exceed the ability of the affected communities to cope using their own resources. Disaster occurs when negative effects of the hazard are not well managed. **(IIRR, 2013)**

Disaster Risk

Probability to meeting danger, suffering or harm. The potential losses in lives, health status, livelihoods, assets and services, which could occur to a particular community or society over some specific future time period. (IIRR, 2013)

Disaster Risk Reduction

Is a framework and a tool that determines the degree of risk and describes measures to increase capacities and reduce hazard impact on the elements at risk so that disaster will be avoided. Disaster Risk Reduction is the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of humans, productive assets and property, wise management of land and the environment, and improved preparedness to adverse events. (IIRR, 2013)

Drought

Drought is deficiency of precipitation over an extended period of time, usually a season or more.

This deficiency results in a water shortage for some activity, group, or environmental sector. Different from other hazards in that it develops slowly, sometimes over years, and its onset can be masked by a number of factors. It can be devastating: water supplies dry up, crops fail to grow, animals die and malnutrition and ill health become widespread. This definition combines Agricultural Drought and Hydrological Drought. **(**IIRR, 2013)

Drought Adaptation Options

Includes all practices that include coping with drought situation. In this study drought adaptation options include all practices that include coping with the negative effects of drought including crop and pasture irrigation practices, livestock diversification, growing drought tolerant crops, keeping drought resistant livestock breeds, among other practices. (IIRR, 2013)

Drought Exposure
Relates to ‗the nature and degree to which a system is exposed to significant drought variations' (IPCC, 2001). Exposure refers to extrinsic factors focusing on character, magnitude, and rate of change the species or system is likely to experience**. (IIRR, 2013)**

Drought Impact
These include all the qualitative and quantitative effects on humans, environment assets in terms of loss, damage and/or injury. (IIRR, 2013)

Drought Readiness
Group/community organization functioning as a system which is prepared for drought disaster that is going to happen. **(IIRR, 2013)**

Drought risk
The probability of meeting danger or suffering/harm associated with drought. (IIRR, 2013)

Drought Sensitivity
Relates to the ‗degree to which a system is affected, either adversely or beneficially, by climate variability or change. 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, 2001). Generally, refers to innate characteristics of a species or system and considers tolerance to changes in such parameters as temperature, precipitation, fire regimes, or other key processes.

Drought Vulnerability
The complex combination of interrelated, mutually reinforcing and dynamic factors. It is the susceptibility of ―elements at risk‖ (humans, livestock, crops, natural resources) in the community to drought. The degree to which an area, people, physical structures or economic assets are exposed to loss, injury or damage caused by the impact of a drought.
This describes exposure of humans, economic assets (including livestock, farms, businesses) to loss, damage and injury caused by impact of drought. Drought vulnerability may be measured through allocation of weighed indices to various factors contributing to vulnerability including exposure, sensitivity and adaptive capacity. (IIRR, 2013)

Drought Vulnerability Assessment
Vulnerability to drought hazard is determined by interactions between Adaptive Capacity, Exposure to drought stimuli and Sensitivity to drought stimuli. Exposure, sensitivity and nonclimatic factors combine to form Impact. The total sum of exposure, sensitivity and non-climatic factors result is Impact, which is deducted from Adaptive Capacity to establish drought vulnerability. (IIRR, 2013)

Drylands

Refer to all terrestrial regions where the production of crops, forage, wood and other ecosystem services is limited by water, which encompass all lands where the climate is classified as drysub-humid (aridity index 0.50-0.65), semi-arid (aridity index 0.20-0.50) and arid (aridity index
0.05-0.20), exclusive of hyper-arid (aridity index <0.05) areas**. (IIRR, 2013)**

Exposure

Exposure is defined as "The nature and degree to which a system is exposed to significant climatic variations‖ (IPCC 2001).

Hydrological drought

Meteorological drought, when prolonged results in hydrological drought with a marked depletion of surface water and consequent drying up of reservoirs, lakes, streams and rivers, cessation of spring flows and also fall in groundwater levels**. (IIRR, 2013)**

Hazard

A potential event that could cause loss of life, or damage to property or the environment. A hazard is a dangerous phenomenon, substance, human activity or condition that may cause the loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (IPCC, 2001).

Impact of drought

Drought impact is defined as negative and positive effects on drought sensitive elements including humans, livestock, natural resources, food availability and prices and the role of droughts on conflicts. Based on the affected elements, it could be deaths in livestock and humans, number of dried water sources or in some cases, the effects may be qualitative. (IIRR, 2013)

Magnitude of vulnerabilities to drought

Note that clear definition and the measurable variables are not given. Magnitude defines the level of vulnerability to drought based on indices from 0 - 1. The indices were allocated weights for every variable in Drought vulnerability assessment including drought adaptation option, drought impact (exposure and sensitivity). The magnitude is expressed in form of Vulnerability Index ranging from 0 - 1. (IIRR, 2013)

Mal-adaptation

Occurs when an action or process increases vulnerability to climate change –related hazards. Mal-adaptation actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits, but can eventually lead to exacerbated vulnerability in the medium to long term (UNDP, 2004).

Mainstreaming Climate Change Adaptation
A process of integrating adaptation considerations into policy-making, budgeting and implementation process at national, sector and sub-national levels. (IIRR, 2013)

Meteorological drought
It is a situation when there is a significant decrease (more than 25%) in rainfall from the normal value in an area. (IIRR, 2013)

Mitigation
Elimination or reduction of frequency, magnitude or severity of exposure to environmental, economic, legal, or social risks, or minimization of the potential impact of a threat or warning. (UNDP, 2009). An anthropogenic intervention to reduce the source or enhance the sinks of greenhouse gases. (IIRR, 2013**)**

Pastoralism
Pastoralism is extensive livestock production in rangeland environments. Principal defining features are livestock mobility and communal management of natural resources. (IIRR, 2013)

Pastoral Production Systems
These are systems that include livestock rearing for cultural and economic purpose in a communally shared grazing land with common access to livestock pasture and water resources. The pastoral production system relies on livestock for more than 80 % of cultural and economic benefits. The term refers to both economic and cultural identity. As an economic activity, pastoral production system involves livestock production in communal arid and semi-arid lands, where key resources such as livestock forage and water are available. Crucial aspects of pastoral production system include: The interaction of people, livestock and environment, particularly strategic mobility of livestock; the development of flexible resource management systems, particularly communal land management institutions and non-exclusive entitlements to water resources. (IIRR, 2013)

Rangeland
Is defined by Society for Range Management as the ―land on which the native vegetation, predominantly grasses, grass-like plants, forbs, or shrubs are suitable for grazing or browsing use‖. Rangeland includes natural grasslands, savannahs, shrub lands, most deserts, tundra, alpine communities, coastal marshes and meadows. (IIRR, 2013)

Resilience
The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase its capacity for learning from past disaster for better protection and to improve risk reduction measures. (IIRR, 2013)

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

40 percent of the earth's surface is covered by Arid and Semi-Arid Lands (ASALs and about 35 percent of human population live in these areas (GoK, 2012). The ASALs are prone to drought. Drought is a normal reoccurring feature of environment and is considered to be one of the most complex and least comprehended of natural threats, impacting more people than any other threat (Hagman, 1984). The data from Emergency Events Data source (www.em-dat.net) reveal that, throughout the globe, droughts account for 5% of the all-natural disasters and losses from droughts have actually caused up to 30% of all losses from disasters, ranking droughts initially amongst all the natural dangers. Furthermore, with the escalation of worldwide environment adjustment, the regularity of droughts and the areas influenced are anticipated to increase sharply (NCAR, 2005; IPCC 2001). Losses from droughts globally have actually increased significantly in tandem with frequency and severity of droughts (Wilhite, 2000) in Zhao et al. (2010). However, in spite of the relevance of drought, limited studies have been accomplished globally on drought vulnerability assessment, adaptation options and impacts of droughts.

Factors contributing to drought vulnerability include magnitude, and rate of climate variation to exposure, sensitivity and adaptive capacity (IPCC, 2001). As observed by Fussel and Klein (2006), the IPCC definition of vulnerability incorporated vulnerability (of a certain system over a specified time horizon) to anthropogenic climate variation. This research greatly counts on the IPCC working meaning of vulnerabilities featuring exposure, sensitivity and ability to adapt (Khajuria and Ravindranath, 2012). Vulnerability is normally described as a feature of three overlapping elements consisting of exposure to danger, level of sensitivity to hazard and

adaptive ability as clarified by Turner et al. (2003Vulnerability is a problem in which people encounter food insecurity, unemployment, social marginalization and wellness (illness and physical weak point) as observed by Zahedi Mazandarani and Zahedi Abghari, 1996 in Zarafshani *et el.,* 2012. Complication of interactions between socio-economic variables and the environment are important in assessing drought vulnerabilities of communities and households according to Headdress *et al.* (2011).

Impact and vulnerability assessments are tools used for pre-drought planning and mitigation that reduces future drought impacts and enhances future drought management (Abraham, 2006). Drought management includes recognizing vulnerabilities, drought preparedness and mitigation measures prior to a drought strike (Zarafshani et al, 2012). As observed by researches in Iran by Karami, (2009); Keshavarz et al. (2012; Zarafshani et al (2012) it was revealed that nationwide drought planning initiatives are mainly based on drought emergency management including water trucking, livestock fodder supply and emergency food and medical supplies for humans. Nevertheless, making the shift from dilemma to risk monitoring is hard because little has actually been done to understand and deal with the vulnerabilities as well as impacts associated with drought.

Panda and Dhanapal (2015) explain that, adaptive capacity is a function of vulnerability. In a study conducted in India showed that there is need for vulnerability assessment across key sectors. However, the methodology to do so is not clear. Baudoin et al (2016), explain drought vulnerability assessment in Kaua'i an O'ahu in Hawai in USA of America, on the North Coast giving a mixed qualitative and measurable review of Very early Caution System in these communities yet could not share the information of what approach was utilized. Drought Vulnerability Analysis data sources worldwide are non-uniform and some information contradict (Delft, 1993). The impacts of drought on socio-economics in terms of high cost of

living, rapid population growth, fast urbanization and other unsustainable development activities significantly contribute to household drought vulnerability (Baudoin et al., 2016). Baudoin et al. (2016) further explain that a high degree of drought vulnerability to all-natural hazards is typically prevalent among the poor households and those situated in remote locations across the world particularly, in the global south where infrastructure like roads, water and communication are poor. They go further to explain that wealthier households are also vulnerable to hazards due to their location. CWCB (2013) used Numerical Assessment Tool for Vulnerability analysis in Colarado State, USA. However, the assessment of magnitudes to vulnerability is not clear.

The main expected results of adaptation gaps assessment are to provide recommendations for specific adaptation strategies. The application of adaptation assessment should be directed to those areas with the greatest exposures and sensitivity to drought as explained by Smith and Wendel, 2006.. Smith and Wandel (2006) further add that, adaptation to drought in the context of human dimensions of global adjustment typically refers to a procedure, activity or outcome in a system (household, neighborhood, group, field, area, country). The author went further to clarify that, the principles of adjustment, adaptation ability, vulnerability, exposure as well as sensitivity are interrelated and have vast application to global climate change science. GIZ (2015) agree with Smith and Wandel (2006) and added that, adaptation is a procedure and not an end result.

According to IDS 2008, there is often no clear distinction between drought adaptation interventions and development interventions. Several adaptation actions consist of a 'development' part, whether unconditionally or explicitly. On the other hand, GIZ, 2015 explain that, drought adaptation concerns are mainstreamed into development initiatives. Because adaptation actions are used in anticipation of future drought effects, they are accompanied by a high level of uncertainty. This research determined clear adjustment actions. Choosing

choices to adapt to international change as well as developing policies to implement these options must be a procedure in which all those who are likely to be impacted have the chance to get involved (Schroter et al., 2005).

Africa contains a substantial section of the world's dry and semi-arid rangeland, extending over 3 million square kilometers and these dry areas support an estimated 16-22 million pastoral population according to Widstrand, 1975 and about 500 million head of livestock according to FAO, 1975 and Lusigi & Oba, 1987. Recurrent droughts and famines are common functions of African rangelands. This has been clearly shown in the Sahelian drought of 1969-1973 and the drought of 1983-1984 which asserted numerous lives as Oba, 2007 explains. Individuals most impacted by recurring drought are the pastoralists' households and their livestock are annihilated and records at the time of drought estimated millions of animals starving accompanied by terrible human suffering (Lusigi and Oba, 1987). The failure of the 2016 October-December rainfall throughout parts of the Horn of Africa resulted in a severe drought in Somalia, South-Eastern Ethiopia, North and North Eastern Kenya resulting in 15 million individuals in these three nations facing food and water shortages, experienced famine according to IAWG, 2016. Additionally, the failure of rainfall during October-December 2016 resulted in a damaging drought throughout parts of the Horn of Africa, Central and Southern Somalia and South-Eastern Ethiopia (IAWG, 2016).

Hume et al. (2005) observed that, there has been relatively inadequate work released on drought vulnerability research subjects for Africa. A study conducted in the Greater Horn of Africa by Omondi et al. (2013) validates that comprehending the qualities of environment extremes such as drought at local and neighborhood degrees is vital for the development of drought preparedness activities, development of very early caution systems and additionally basic in developing drought adjustment approaches. A few of the methods are ecologically based, while others rely on socio-economic systems according to Lusigi and Oba, 1987. Expanded social

security programs, reinforced accessibility to lasting water, sustainable natural resource management and applied early caution systems and insurance coverage schemes in Eastern Africa has positively contributed to drought resilience according to IAWG, 2016. Despite the devastating effects of droughts, adequate studies on impact of drought on pastoralist have not been adequately conducted in Africa.

2010 - 2011 study by Omondi et al. (2013) indicates that this period was the driest period in sixty years with more than 12 million persons in need of emergency food and medical aid in the Greater Horn of Africa (GHA). Other severe droughts also occurred in 2014, 2017, 2021 and 2022. In addition, Omondi *et al.* (2013) explain that, like most African countries, GHA countries have short and or fragmented climate records, often as a result of armed conflicts at various times in the last fifty years. In some cases, the offered documents are too few to be used for the ample circulation of environment patterns. However, the few documents are still useful in offering standard for future analyses, along with monitoring on inter-annual climate irregularity adds Omondi *et al.*, 2013. In the same research study, Omondi et al. (2013) concluded that there is inadequate in situ information for nation analysis that supplies adequate information for national drought vulnerability assessment. In a majority of African countries there is inadequate data to conduct drought vulnerability assessment. Long term sustainable measures have been used in climate adaptation approaches in Africa but have not been effective according to GIZ, (2015). More of such studies need to be conducted in Africa.

Kenya's Arid and Semi-Arid Lands cover 89 percent of the land area and supports the livelihoods of 18 million persons and about approximately 70 percent of national livestock herd according to GOK, (2019). Droughts in Kenya are recurrent affecting more than 10 percent of Kenya's population including losses of up to 50 percent of livestock herds every two - five years when it occurs according to Onono et al (2016) . Kenya has actually determined its

ASALs as the most prone areas to drought with huge influence on livestock production, small-holder irrigation and tourism, which are leading sources of livelihoods in these locations according to Onono et al., 2016. For livelihoods that rely exclusively or partially on livestock, the resulting high livestock death rate has destructive effects, resulting in pastoralists being amongst one of the most drought vulnerable communities in Kenya observes Mude, (2009).

Kenya in the last 25 years experienced long term completely dry durations that affected millions of individuals as well as killed significant numbers of livestock specifically in the Arid and Semi-Arid Lands according to Ogwell, 2011. Severe droughts have been recorded in 1960/1961, 1969, 1973/1974, 1981/1981, 183/1984, 1991/1992, 1995/1996, 1999/2000, 2004/2006, 2008/2009 and 2010/2011 (Onono et al., 2016). Where dryness is most conspicuous in northern Kenya, in the past 100 years, 28 major droughts have been recorded observes Schilling and Remling, 2011. According to pastoralists, rainfalls use to fail every nine or ten years. However, they now experience drought every two or three years report Schilling and Remling, 2011. The questions that arise include, why does such a regular and predictable phenomenon lead to suffering, loss of livelihoods and sometimes loss of life? Lack of adequate information on magnitudes of vulnerabilities to drought, inadequate studies on adaptation options and impacts on drought on pastoral production systems have resulted in poor intervention measures.

From disaster records nationally, in the National Policy for Disaster Management, (2009), in 1975, 1977, 1980, 1983/1984, there were widespread droughts in Kenya that affected 20,000 1975,, 40,000 1977, 4,000 1980 and 200,000 in 1983/84 persons. In 1995/1996, there was widespread drought that affected 1.4 million persons nationally. The El Nino floods of 1997/1998 affected 1.5 persons nationally. In 1999/2000, there was a major drought in the country that affected 4.4 million persons. In 2004, the country experienced severe drought that affected 3 million persons needing relief food for a period of eight months. In 2006, there were

floods in Laisamis that displaced 5,000 persons NPDM, (2009). Adequate studies have not been conducted to assess the vulnerabilities of local households to various disasters including drought.

According to Nkedianye *et al.,* (2011), Kenya‘s Arid and Semi-arid Lands have faced increasing drought frequency and intensity since the 1960s and are one of the most drought vulnerable regions in the world. Throughout Kenya and the arid parts of the country, droughts have resulted in undermining community livelihoods adds MEMR, (2009). The long term droughts of the past years have resulted in food insecurity and undermined other socio-economic dynamics pastoral areas according to Economist (2009), GOK (2007b), and UNDP, (2007) reports. Natural resources are the backbone of Kenya's economic situation making it vulnerable to climate related variation including drought adds GOK, (2014). There is vital need to carry out drought vulnerability assessments to determine appropriate interventions notes MEMR, (2009a). There is need to determine factors contributing to drought vulnerability and identify options that may mitigate effects of drought on pastoralists at micro-level in rangelands of Kenya explain Deressa *et al.,* 2008, Pearson et alia 2008, Sherwood 2013 and Opiyo *et al.,* (2014).

According to GOK, 2010, the country's vulnerability to drought differs depending upon the area and this therefore implies that specific vulnerability assessment is required for each area. Dhanapal, 2014 adds that recognition of drought prone areas and other climate variations related disasters have not been undertaken in various counties in Kenya. Opiyo et al., 2014 explain that household vulnerability assessment is currently being carried out in isolated location in Kenya and limited studies have been undertaken at regional and national levels. According to GOK, 2010, there is limited information on Kenya's drought vulnerability assessment, drought impacts assessment and options for adaptation to drought. There is limited

study on drought vulnerability assessment amongst pastoralist households and other communities living in high rainfall areas.

Kenya's temperature level has actually risen by 1 degree centigrade over the last half a century according to NCCAP (2018 – 2022) and NAP (2015). Schilling *et al.,* 2011 explain that, because of climate variation and drought phenomenon, the nation is heating at the rate of approximately 1.5 times the global standard and is projected to increase approximately 2.8 levels centigrade in 2060 and as much as 4.5 degrees centigrade in 2090. Kabubo-Mariara, 2009 and Silvestri et al. 2012, expose that extreme climate occasions such as long term droughts and extreme rainfall failures are already influencing negatively on pastoral communities in arid and semi-arid parts of Kenya. The data sources for drought vulnerability assessment are non-uniform and some information resources present negating details explains Delft, 1993. Vital data from households to evaluate vulnerability assessment is currently lacking at national and county levels explains Opiyo, (2014). There is no sufficient data and financial resources to carry out drought vulnerability assessment at nationwide level. No substantial vulnerability research studies have actually been executed at household levels.

Obstacles faced by the pastoralists in the study area are drought and scarcity of livestock forage, rapid population growth, loss of common property especially land to investors and sedentarisation defines Elliot, (2004). High levels of drought vulnerability to drought and in the research study area is linked to high dependence on natural resources, limited ability to adapt economically and institutionally, low per capita income, high poverty levels and lack of safety nets according to PACIDA, 2009. Coping and adaptation methods applied by the pastoralists consist of mobility, herd diversity, herd splitting or merging, sale of livestock and income diversification amongst explains Lekapana, (2013).

Research conducted in Marsabit by Lekapana, (2013), established that livestock deaths, food insecurity, reduction of livestock prices, and rise in food prices were among the socioeconomic factors contributing to high drought vulnerability of households. Lekapan (2013) adds that human mobility, drought skilled preparedness and drought mitigation skills are variables contributing towards reduction of drought vulnerabilities of households. Pastoral areas in Marsabit Region have utilized a number of coping and adaptation strategies to deal with the impacts of recent droughts on livelihoods according to Lekapana, (2013). However, due to poor documentation and inadequate research, there is limited knowledge on pastoralists' drought adaptation strategies adds Lekapana, (2013). Despite the threats posed by the recurrent droughts to pastoralists livelihoods in the study area, adequate research on vulnerabilities, adaptation options and impacts of drought have not been carried out due to lack of or inadequate financial resources.

1.2 Statement of the Problem

The communities inhabiting pastoral areas are highly vulnerable to drought. However, the drought vulnerability levels, adaptation options and drought impacts on pastoralists production systems not well studied and understood. This has led to poor interventions by development organisations. The relevance of the study is focused on documenting drought management while while understanding its vulnerability specifically, drought impacts and adaptation options. Since there is limited research on these areas, scientists, extension workers, development organisations and pastoral communities may benefit from these research findings.

Despite the importance of drought on livelihoods, adequate studies on drought related research has not been carried out., Data on drought vulnerability at global, Africa, national and community levels are inconsistent, non-uniform and unreliable (Gray et al, 2012). There are short and fragmented records on climate related hazards including drought resulting in poor

understanding of the drought phenomenon. Most studies discuss vulnerabilities in general terms (Hummel et al, 2016). The magnitude and distribution of drought vulnerabilities are not well understood. Therefore, there is need to assess levels of vulnerability of livelihood and other economic and social-economic factors related to climate variability including drought. This study combines drought vulnerability assessment, drought impacts and drought adaptation. Most studies have only one component for example only rainfall,which makes drought management difficult for communities and decision makers at national government levels.

The adaptation capacity gaps and impact of drought on pastoralists are not well understood and documented especially in Eastern Africa including Kenya, Ethiopia, Somalia and Djibouti. Drought adaptation options are not well researched, recognized and documented. Besides separated researches performed in West Pokot by Muricho et al (2019) and Turkana conducted by Opiyo et al. (2015), there are no critically analysed data.. Majority of the analysis is carried out at national or county levels. Researches on vulnerabilities, impact and options for adaptation to drought by pastoralists households in Kenya. are limited on pastoral livestock production systems. Therefore, the purpose of this study was to assess vulnerabilities to drought, assess impacts of drought and adaptation options of pastoralists' livelihoods.

1.3 Objectives of the study

1.3.1 General Objective

The general objective of the study was to assess drought vulnerabilities, impact and adaptation options of pastoralists production systems in Laisamis Sub-County, Marsabit County, Kenya.

1.3.2 Specific objectives

1. To assess magnitude of vulnerabilities to drought in pastoral production systems in Laisamis in Marsabit County.

2. To determine impacts of drought on pastoral production systems in Laisamis in Marsabit County.
3. To determine the adaptation options to drought in pastoral production systems in Laisamis in Marsabit County,

1.4 Research Questions

1. What is the magnitude of vulnerability to drought in pastoral production systems?
2. What are the impacts of drought in pastoral production systems?
3. What are the adaptation options in the pastoral systems?

1.5 Justification of the Study

Droughts have a great impact on pastoral area of the world by reduction of livestock forage production and water resources. Drought is a significant contributor to poverty in pastoral communities of the globe as it leads to livestock deaths and causes reduction of assets. Pastoral production systems are the sub-sector most susceptible to drought due to its high reliance on climatic variables including rainfall, temperature, moisture and wind speeds. However due to gaps in data availability globally, at continental, national and study area levels, it has been difficult to understand the drought phenomenon including vulnerability, adaptation options and impacts on pastoral production systems, Zarafishani et al (2012)_. It has been difficult to intervene appropriately by development organizations.

Exposure to drought hazards may directly render many households food insecure through disruption or has the potential to disrupt pastoral production systems, Fussel et al (2014). Various studies have been conducted on the physical facets of droughts and how communities respond to it. However, few studies have actually made comprehensive drought vulnerability assessment and identified adaptation choices among pastoralists explain Dube and Sekhwela, (2007), Eriksen and Silva, (2009} and Mogotsi et al., (2011.

Droughts are having significant negative impacts on socio-economic loss and in some rare famine cases human deaths, Abate, T (2013). Economic assets like livestock are highly vulnerable to drought in Sub-Saharan Africa among individuals, households and establishments such as commercial ranches, Biazin et al (201). Climate variability and unpredictable nature of droughts have compounded the difficulties for preparedness, mitigation and recovery through indigenous approaches. This implies that application of modern technology, for example collection of data and analysis for drought prediction through remote sensing is necessary, Birhanu et al (2021). Climate variation is more threatening not just to the lasting advancement of socio-economic and agricultural production of any nation but to the totality of human existence. This requires detailed research studies on recognizing drought vulnerabilities, adaptation options and its impact to ensure that appropriate interventions are made.

Challenges faced by pastoralists include changes in rainfall patterns, increased regularity and seriousness of droughts, rapid sedentarisation occupying important grazing land, fast population growth and decreased fodder accessibility especially throughout the dry periods, reduced milk and meat productivity and poor infrastructure like roads explains Kaufman, (2012). Direct exposure to drought prone locations and sensitivity of the income systems to climate variability makes pastoralists very vulnerable to drought. This study will certainly add to a broadening understanding on vulnerabilities to drought, adaptation choices as well as drought impacts on pastoral livestock systems and enhance broaden understanding of exactly how climate variation affects communities in the pastoral areas, Muricho et al (2019)

Conclusions may be drawn concerning drought vulnerability levels,impact of drought and adaptation options among pastoral production systems by comparing the findings of this research with other pastoral systems in the world. Researchers, academicians, development

organizations, Government of Kenya and communities can benefit from the outcomes of the research. Researchers may replicate the same approach in other areas or identify gaps and improve in further research.

The study was conducted on vulnerabilities of pastoralists to drought and would be useful for researchers in understanding the vulnerabilities faced by pastoralists not only in Kenya but the Horn of Africa region, Africa and the globe. The study is useful for proper targeting of pastoralists during drought interventions for women, youth and the elderly after assessing drought vulnerabilities, impac and adaptation optionsThis is expected to provide clear road map for drought intervention agents. .

1.6 Scope of the Study

Rendile and Samburu livestock pastoral production systems in Laisamis Sub-County, Marsabit County was covered by the study. The study area covers Laisamis, Log Logo, Korr and Ngurunet Wards. Other parts of the Sub-County including Loiyangalani, Mt. Kulal, Kargi and South Horr were not covered by the study. The excluded areas are mainly high rainfall or insecure areas.Laisamis-Sub County, Logologo, Ngurunet and Korr were selected because these areas are usually marginalized in development . The urban communities in the areas included were not covered by the study. The study mainly worked with villages close to the urban centres.

There were a total of 6,182 households in the study area according to record obtained from Kenya National Bureau of Statistics, 2019 and the study used a sample of 384 households. The study was based on the theory based on the formula V= AC - (S+E) of IPCC (2007). Where V is Vulnerability, AC is Adaptive Capacity, S is Drought sensitivity and E is exposure to drought. The objective of the study is limited to assessing household drought vulnerabilities, determine impact of drought and assess options for adaptation to drought.

1.7 Study Limitations

The study experienced limitations in access to long-term rainfall data from the various centres in the study area. There were no manned meteorological stations in the study area. Access to research documentation from the study area was difficult because limited studies on the subject of research were carried out in the area. Transport was a challenging due to bad all weather roads in the study area. A four wheel drive vehicle was used during data collection. No insecurity situations were experienced during the study though the area is prone to sporadic and unpredictable conflicts and highway attack situations. Due to prevailing drought condition in the study area during data collection, most of the male household heads were not available to be interviewed and as a result there were high numbers of females who were interviewed. The women interviewed were found to be competent to give reliable information about their households even with the absence of the spouses. The field assistants made sure that mainly heads of households were interviewed, though they are from female gender.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

Chapter two examines past studies conducted on drought vulnerability assessment in pastoral production systems, adaptation options and impacts of drought. The literature review was divided into four sections related to the three objectives of the study and conceptual framework. Literature was analysed and critique views from array of scholars, academics and other contributors globally, in Africa, nationally and from the study area. Section one will include Drought Vulnerability Assessment in pastoral production systems. The second section reviewed and analysed options for adaptation to drought and the third section examines impacts of drought on pastoral production system. The fourth section of this chapter describes Conceptual Framework that forms the basis of this study. The key literature to be reviewed included peer journals, scientific papers, PhD and MSc theses, authoritative reports from reputable national and international institutions.

2.2 Magnitude of Drought Vulnerability Assessment in pastoral production systems

There are many definitions of vulnerability. However, the most commonly applied in the climate change literature is given by IPCC, 2001 as, ―the magnitude to which a system is exposed to or not able to cope with, impacts of climate variations, including environment variability and extremes. Turner et al. (2003a) explains that, drought vulnerability is commonly referred to as a feature of three related components including direct exposure to danger, sensitivity to threat and adaptive capability. Fussel and Klein, 2006 adds that, the IPCC meaning of vulnerability may be modified to integrated vulnerability to anthropogenic environment change.

Though there are numerous studies conducted at global level, there are gaps in conducting comprehensive studies that consider the key factors contributing to drought vulnerability. Drought vulnerability is not well understood by scientists and development practitioners. Vulnerability is often used interchangeably with risk. Vulnerability implies exposure to hazard, while risk implies the probability of getting harmed. Vulnerability mainly describes presence and expose to hazard, while risk has the main element of capacity or ability to cope with the hazard.

Abraham, (2006) explains that drought vulnerability incorporates diverse set of techniques utilized systematically and considers communications between human beings and their physical and social environments. Parannelo, (2009) adds that, drought vulnerability assessment emerged to address the need on how communities would adapt to changing environmental conditions. Vulnerability assessment recognises multi-dimensional idea including bio-physical, economic, institutional and socio-economic elements that would contribute to ability to handle stress and anxiety and shock of environment related hazard such as drought explain Khajuria and Ravindranath, (2012). Erian, (2010) and Khajuria et al., (2012) explain that, conventional methods of drought vulnerability assessment and surveillance rely upon rainfall data, which are difficult to access, usually inaccurate and challenging to acquire in near-real time

Smith and Wandel, (2006) explain, that *exposure* and *sensitivity* are closely related properties of a system (or community) and are dependent on the linkages with adaptation choices. Exposure may include geographical location related to for example, people staying in the location of natural calamities such as drought or seaside areas and river basins prone to flooding. Level of sensitivity and flexible capability are context specific and differ between locations. The same writers additionally explain that flexible ability as the capacity of a system to get used to climate adjustments, may determine impacts of drought and choices of

adaptation. However, the writers were not able to explain the relationship of sensitivity, exposure to hazard and capability to adaptation. Additionally, Fussel, (2005) recommends that four basic dimensions need to be taken into consideration throughout vulnerability assessment i.e. the livelihood systems, region or geographic location, valued features or components of the prone system as well as the temporal reference, that is the time period. The Hazard to be considered in this case is drought and exposure to drought prone areas including ASALs forms a basis for assessing vulnerability.

Various attempts have been made to assess vulnerabilities. However, the studies are not comprehensive and leave out key factors contributing to vulnerability for example livelihoods, mentions Dhanapal, (2014). Vulnerability may be assessed through adaptive capacity determinants explain Turner et al, (2003a), Schroter et al, (2005), Vogel and O'Brien, (2006). Community-based interactive techniques for identifying causes and frameworks that form vulnerabilities are used, explain O'Brien et al, (2004). Drought vulnerability is also examined in relation to severe climate events such as droughts as well as flooding describe Osman-Elasha et al., (2006). By using indices such as Livelihood Vulnerability Index (LVI) it is possible to determine vulnerability explain Hahn et al., (2009). The writers applied one or two components to assess community vulnerabilities. The writers acknowledge that the limits of these methods, in particular that no solitary action will certainly be able to totally cover the multiple dimensions of drought vulnerabilities. Minimal qualitative descriptions of a solitary specification of vulnerabilities are not constantly valuable to link into components for vulnerability assessment. The variations in vulnerability assessment approaches and the lack of measures on adaptive capacity have led to weak adaptive planning and ad hoc estimation of adaptation costs explains Dhanapal, (2014). This challenge has led to a great deal of thinking about vulnerability assessment and how they can be improved. This study attempted to

combine all the key parameters including exposure to hazard, sensitivity and adaptive capacity to provide a comprehensive assessment of vulnerability.

Four stages of vulnerability assessment including Impact Assessment, First Generation Vulnerability Assessment, Second Generation Vulnerability Assessment and Adaptation Policy Assessment were applied by Fussel and Klein, (2006). This method lacks the logic and has contradictions in assessing the different determinants of vulnerabilities. For example, Impact

Assessment is based on *exposure* and *sensitivity* of which the authors are silent on. Adaptation directly contributes to vulnerabilities and the authors lacked consistency in explaining this.

Opiyo et al, (2014) explain that various approaches to vulnerability assessment include socioeconomic, bio-physical and an integrated method which unites both socio-economic as well as bio-physical aspects. Fussel, (2005) suggests that a number of scientists distinguish between biophysical or natural vulnerability from socio-economic susceptibility. Nevertheless, there is no concurrence on the definition of these terms. Fussel, (2005) adds that, the theoretical framework for coastal vulnerability analysis developed by Klein and Nicholls, (1999) considers natural vulnerability as one of the factors of socio-economic vulnerability. Fussel, (2005) and Cutter (1996), on the other hand maintain that, biophysical and social dimensions of vulnerability are independent. Brooks, (2003), suggests that social vulnerability might be considered as among the components of biophysical vulnerability. Fussel, (2005) says that bio-physical and socioeconomic vulnerabilities are unrelated and none of them allows to continually incorporate the other. He goes additionally to clarify the reason for the failure to distinguish between the two mainly independent measurements of vulnerability including exposure and sensitivity. Vulnerability cannot be assessed without clearly considering the two components concurrently argues Fussel, (2005) and uses the term *vulnerability* and *risk* to

mean the same. The terms have different meanings as described in the Terms in the earlier part of this thesis.

Global drought vulnerability is the possibility that a given human-environment system will experience injury from direct exposure to hazards related to changes of societies and environment and making preparations for drought mitigation explain Schroter et al. (2005). They further explain worldwide drought vulnerability assessment which includes not only the analysis of vulnerability but also includes identification of alternatives for stakeholders to mitigate the vulnerability to drought. However, the writers fail to recognise that adaptation capacity gaps need to be identified before considering adaptation choices. Opiyo et al., (2014) explain that some parts of the globe have inadequate data, while others have contradicting data. The countries without adequate data bases are mainly due to poorly developed infrastructure and inadequately trained technicians.

A framework for drought vulnerability assessment established by scientists in collaboration at Stockholm Environment Institute (SEI) and Clark University in the United States of America shows complexity and interactions associated with drought vulnerability. Thomalla et al., (2006) shows how multiple socio-political and physical processes contribute towards increase in vulnerability. At international level, satellite-sensor data are consistently available and can be used to predict drought through early warning system explain, Thiruvengadachari and Gopalkrishna, (1993) in Erian, (2010). Several drought indicators have been utilized in Europe such as Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Standardize Precipitation Index (SPI), Vegetation Condition Index (VCI), Temperature

Condition Index (TCI), Vegetation Healthy Index (VHI) and Soil Moisture (SM) according to Erian, (2010). However, each of the described methods only addresses single aspect

contributing to drought without linking the various components of drought including precipitation, vegetation, temperatures and soil moisture.

Palmer Drought Intensity Index Penman-Monteith technique (PDSI pm), was applied for years, that is, (a) 1950-1959, (b) 1975-1984, (c) 2000-2009. 22-model ensemble-mean surface area air temperature, rainfall, humidity, radiation, as well as wind speeds has been used in countries including Syria, Iraq and Saudi Arabia according to Wells et al, (2004). MODIS images has actually additionally been made use of to supply near real-time, constant as well as relatively high-resolution information, on which the assessment of drought and extent at national or local area level with limited spatial coverage adds Erian, (2010). These methods only indicate the trends in the drought without providing levels of drought severity or vulnerabilities of various elements including human and productive assets. Additionally, the measurements are not able to provide information on drought vulnerabilities but only provide information on drought severity.

Erian et al. (2010) identified three main steps in drought vulnerability assessment in Syria, Iraq and Saudi Arabia that is, a) Producing drought frequency information for ten seasons, b) Successive dry spell periods were also approximated showing the geographic coverage, (c) Production of drought map. This method only provided drought vulnerability without indications on levels of vulnerability. There is need for figures indicating levels of vulnerability either in form of indices or percentages.

Various methods and approaches have been used in different parts of the globe for vulnerability assessment with merits and demerits. Polsky et al. (2007) in Mekong River Commission, (2010) suggest a vulnerability scoping diagram, which is not comprehensive enough as it excluded the key determinants of vulnerabilities including hazard, sensitivity and adaptive capacity. Vulnerability assessment presents challenges in ensuring that the relative nature of

vulnerability is not lost during data collection and analysis. Eakin and Bojorquez, (2007) offer an approach of weighing factors for drought vulnerability assessment. In a study in China, Liu et al. (2013) used a framework to highlight the favorable impacts of human activities in the coupled human and allnatural system (CHANS) by presenting flexible capability as an analysis criterion for drought vulnerability analysis.

A built-in local vulnerability to drought risk was generated based upon interaction of three measurements of vulnerability that is, exposure, sensitivity and flexible capacity according to Liu et al, (2013). Barrett et al., (2014) used an assessment referred to as "participatory social risk vulnerability mapping" in Bangladesh. This method is not reliable as there is a mix-up between the term "risk" and "vulnerability". Additionally, the authors could not explain what the relationship is between the two terms. The authors also indicate that impact assessment is the predecessor to vulnerability and were not able to describe the relationship between impact and vulnerability.

In Ceará, Brazil, communities are extremely vulnerable to recurrent droughts describes Paul et al., (2014). Formalized drought related research tasks on vulnerabilities are not prominent among academic establishments explain Paula et al, (2014). In a research study in Chihuahuan desert, U.S.A, Brown et alia, (2016) suggested that a much more structured, systematic method of evaluating drought vulnerability in private ranches is necessary. Incorporation of socioecological components into vulnerability studies can significantly contribute towards development of more practical techniques to climate variability studies. Drought policy and programs need to be built within vulnerabilities of the whole socio-ecological system in mind, with the objective of preserving sources, processes, and services describes Brown et al., (2016).

Participatory risk assessments referred to as "social vulnerability mapping" has been applied in Bangladesh (Barrett et al., 2014). This method mixes the terms "risk" and "vulnerability". Panda and Dhanapal, (2015) mention that vulnerability is a function of adaptive capacity. However, they could not explain the components of adaptive capacity. Panda and Dhanapal, (2015), in a study conducted in India, indicate that there is need for conducting drought vulnerability assessment across the key sectors as addressed by this study. Additionally, Boudoine et al., (2016) in a study in Hawai, discuss community vulnerability assessment through qualitative and quantitative critique of Early Warning System (EWS) but fail to provide the details of what components were considered. The EWS described lacked the key components including scientific base for data collection, analysis, interpretation and response.

It is believed those 20 million pastoralists households are found worldwide notes Blench, (2001). 268 million pastoralists live in Africa alone according to Africa Union figures explains Dima, (2011). Pastoral systems are grassland based production systems with more than 90 percent of the household income resulting from livestock production system and more than 90 percent of the livestock fodder comes from natural rangeland vegetation explain Sere and Steinfield, (1996). This dependence on grasslands for livelihoods makes pastoralists in Africa highly vulnerable to drought. Similarly, a study conducted by Erian, (2010) in Arab speaking countries including Sudan, Tunisia, Algeria, Morocco and Somalia are under severe drought vulnerability. Most studies in Africa use large-scale drought vulnerability assessments which provide very little information that is of practical use for decision makers on the precise extent for specific locations explain Nkomo *et al.*, (2006).

According to IPCC (2012 large numbers of households are particularly vulnerable to drought in the arid and semi-arid regions of Africa. Three factors that are relevant to the Africa region

include migration, access to water resources, conflicts and terrorism are key contributors towards drought vulnerability according to Deka et al., (2011). Drought vulnerability mapping incorporates data on a wide range of factors including unemployment, poverty levels, access to medical services, good governance and the country's ability to respond to future crisis adds Deka et al. (2011).

Hahn et al, (2008) add that, drought vulnerability is not only caused by climatic factors, but also socio-economic, political and environmental parameters. Majority of studies conducted in Africa, mainly focused on the vulnerabilities to climate change and do not address drought vulnerabilities. Hulufu, (2011) describes that development interventions combined with increased human and livestock populations, poor access to livestock and other livelihoods choices and pressure on pasture and water resources have largely contributed to drought vulnerability and climatic shocks among pastoralists in Africa.

Madu, (2012) applied an integrated method in an agro-ecological scenario in Ethiopia for vulnerability assessment among households. Deressa et al. (2008) also applied a similar method for a regional vulnerability evaluation. The research technique was embraced by Tesso et al. (2012) and Opiyo et al., (2014). Graciela et al. (2014) recommended this method of combining the biophysical and socio-economic viewpoints to improve understanding of vulnerability to drought. The writers go further to discuss that, the shift in the direction of a system-based approach calls for modifications in how this sort of study is carried out, needing multidisciplinary, multi-scale, multidimensional and participatory techniques. Opiyo et al., (2014) observed that vulnerability evaluation to drought is required at the degree that would certainly make it possible for policy makers to make accurate decisions on drought preparedness and mitigation measures, especially in the arid and semi-arid regions of Africa.

The writers further explain that, the percentage of households vulnerable to extreme weather conditions is considered to be increasing in arid environments of Eastern Africa. However, no mention of the numbers and magnitude of the vulnerable population or percentages are indicated.

Augustine et al. (2015) used a participatory approach for drought vulnerability assessment in Western African Sahel. This approach applies qualitative approaches including focus group discussion, meetings of semi-structured nature, discussions with open-ended results, community consultations, and interviews with key informants and role plays in examining vulnerabilities at household or individual levels. Augustine et al., (2015) adds that, the good attributes and strength of participatory vulnerability assessment is that they focus on the previous understanding of the communities that have actually been impacted by climatic factors and other shocks. The authors conclude that this method is frequently used by non-governmental organizations in Sub-Saharan Africa, Latin America and parts of Asia to enhance connections among communities and assist in approaches to interventions to minimize vulnerability to climatic hazards such as drought. However, some NGOs are known for using this kind of approach in a functional way in order to fulfill donor conditions to raise project funds. This approach has a challenge of consolidating all the information collected and synthesised in an objective manner.

Using Drought Vulnerability Indicator (DVI) computed at national level, categorised Somalia, Burundi, Niger, Ethiopia, Mali and Chad as countries with higher relative vulnerability to drought according to Shiferaw et al, (2014). This approach of measuring drought vulnerability has actually not been duplicated in other countries of Africa. Additionally, Ricci et al., (2015) and Augustine et al., (2015) established a participatory vulnerability assessment structure for

community actors in Sahel, Bobo-Dioulasso, Burkina Faso. Nevertheless, this structure has actually not been used by the writers and therefore stays academic.

Even with its vulnerability to drought and widespread hardship, the ASAL areas of Kenya have prospective for adding to economic advancement of the nation and it is said to have over 70 percent of the livestock population and over 90 percent of the wildlife which supports the tourism sector according to GOK, (2008). The drought prone areas in Kenya have actually increased in size and now cover 23 counties mostly in areas that are experiencing the highest level of poverty in the country add GOK, (2005). Kenya's arid and semiarid lands (ASALs), which have experienced frequent and severe droughts since the 1960s, according to Nkedianye et al., (2011) in Opiyo et al., (2015. Kenya is prone to calamities caused by conflicts, slow-onset all-natural disasters including droughts, famine, and rapid-onset disasters like flooding.

The dry and semi-arid lands (ASALs) covering about 89 percent of the complete land mass and home to about 36 percent of the national population are frequent impacted by droughts causing food insecurity, high degrees of malnutrition-related health problems and human deaths, as well as interruption of incomes notes, DI, (2017). This scenario indicates high vulnerability to drought among the pastoralists of Kenya. The environmental issues and drought vulnerabilities of pastoralists are poorly recognized or acknowledged. The loss of dry grazing during severe droughts to sedentary farming communities including Aberdares and Mt Kenya forests have significantly contributed towards increased drought vulnerability. Narrowing environmental flexibility as a result of urbanization, loss of drought-adapted livestock breeds, human migration from rural to urban areas, the loss of medicinal plants and reduced biodiversity have negative effects on communities already facing drought hazard adds, Western, (2002).

A research study by Western, (2004) in Kajiado shows land losses by the Maasai consisted of the very best grazing land in the Rift Valley, Laikipia area and the southerly Kenya, specifically in Kajiado County. The loss of Tsavo West, Nairobi National Park and the Kilimanjaro environs took away considerable grazing areas and important drought grazing areas from Maasai usage thus making them highly vulnerable to drought adds Nkedianye, (2011). The wettest parts of Kajiado have been taken up by crop farmers, further denying grazing access to large numbers of livestock kept by Maasai communities especially cattle explains Ndekianye, (2011). The Maasai lost over one-half of their grazing lands, including the rich savannas around Lakes Nakuru and Naivasha, when government treaties in 1904 and 1911 moved them south of the railway line into present day Kajiado and Narok Counties adds Fratkin et al., (2004).

In Northern Kenya, Samburu pastoralists gave up Laikipia plains to European livestock commercial ranchers in 1934 in exchange for use of the Leroki Plateau in present day Samburu County according to Fratkin et al, (2004). Similar scenarios in Narok and Turkana have made pastoralists more vulnerable to drought because of limited access to traditional grazing land. Confined to 35,000 km. square in Kenya and 60,000 km. square in Tanzania i.e. 60 per cent of their pre-colonial grazing area was lost to urbanization and crop farmers. The Maasai were further restricted from grazing their cattle in the large game reserves, including the vast Serengeti Park and Ngorongoro Crater in Tanzania describes Fratkin et al., (2004). In Kenya, the taking over of the Nairobi National Park, Amboseli, Tsavo, Mara Maasai, and Samburu Game Parks exacerbated drought vulnerability of pastoralists in various parts of East Africa adds Opiyo et al., (2014). These situations have exposed pastoral communities to high vulnerability to drought. Therefore, there is need to facilitate limited access by communities to graze in these parks especially during severe drought periods to mitigate drought situations.

Consequences of land fragmentation, loss of mobility within the rangelands, land degradation, hardships of high food prices exacerbated stresses of drought in pastoral areas including Kajiado and Amboseli have increase vulnerability levels of pastoralists describes Western, (2002). Perception against pastoralist that, they are ungovernable mobile herders additionally played a significant role in national government‘s efforts to sedentarize and enable tax collection from pastoral communities explains Western, (2002). Sedentarization led to water sources drying up earlier than usual, dominance by invasion and low nutrient livestock feed plants resulting in reduced adaptability to droughts describes Nkedianye et al., (2011). Cumulatively, these variables increased the environmental susceptibility of pastoralists‘ livelihoods and their livestock.

Ongoing land losses in pastoral areas led to drought refugees and exacerbates vulnerability of households obtaining their livelihoods from land with no access to alternate income sources. According to Fratkin et al., (2004), Maasai dealt with competition for land by both venturing into crop production and leasing their land to companies and individuals producing grain such as barley and wheat and dairy production, especially after Kenya attain independence in 1963. The process of land privatizing to private hands has resulted in long-term loss of large swaths of grazing lands. Along with land given to livestock breeders as well as farmers and converted to national parks, Maasai have experienced loss of valuable grazing lands explain Fratkin et al, (2004). Both the colonial as well as independent national governments have viewed pastoralism as an inefficient and out-of-date method of livestock production mostly wrongly blamed for the state of the degraded rangelands.

Various government schemes have been attempted at modifying pastoralists to engage in more efficient and effective production. However, the policy makers were not able to understand the complex pastoral production systems resulting in harmful effects on the livelihoods and undermining the traditional drought adaptation options by pastoralists explains Western,

(2002). This largely contributed to Maasai community's high vulnerability to drought and weak adaptation capacity.

In a study in Turkana, Opiyo et al., (2014) used an approach similar to Madu, (2012) in determining drought vulnerability index i.e. the use of the formula, Vulnerability Index = Adaptive Capacity - (Sensitivity + exposure). In all the calculations, the figures by Opiyo et al, (2014) were negative. Given that the minimum index is 0 and the maximum is 1, figures of less than 0 indicate that the households have no resilience and are expected to have perished. The fact that they are still surviving is an indication of their resilience and the Vulnerability Index should at least be close to 0 but not negative figures. Wakhungu, (2013) in a study in Turkana shows that the high frequency of drought allows no time at all to recoup in between droughts and this implies that pastoralists experience high vulnerability levels and climatic shocks. Drought has continued to be one of the significant disasters that contribute to higher vulnerability among the nomadic pastoral communities. Mutu et al, (2017) explain that, the slow recovery from droughts result in severe drought impacts because of accumulative influence over duration. Regardless of the hardships, the nomadic populations in the Ilemi Triangle belt in Turkana area have never abandoned livestock keeping as their main source of income explain Mutu et al, (2017). The lesson to be learnt from the Turkana pastoralists is that, traditional drought mitigation works for them and may be replicated in other parts of the country and the globe.

In a drought risk study by DI, (2017) based on Index for Risk Management (INFORM), Mandera county recorded a risk index of 7, the third highest risk score in Kenya after Garissa and Turkana counties. Migori County is ranked 17 with an index of 6.1 and with a higher exposure to natural disasters specially floods. Based on the same study, Mandera was allocated Drought Vulnerability Index of 6.7, while Migori was allocated 4.4. However, the study did

not focus on drought alone but considered other hazards including floods and disease outbreaks, resulting in unreliable analysis of drought vulnerability assessment. The study should have compared areas with similar pastoral livelihoods, environmental and socio-economic challenges. These findings corresponds to a study by Nkedianye et al, (2011) that shows Kenya's arid and semi-arid lands including Turkana, have been exposed to drought risk since 1960. This long history of drought frequencies and severity has hindered recovery from droughts according to Angassa and Oba (2007). As a result, this has motivated researchers to enquire and find out the primary drought vulnerabilities to this population and recommend what may be applied for drought preparedness and mitigation.

Under British colonial rule, pastoralists in Kenya including Rendille and Samburu were restricted to particular tribal grazing areas and prohibited from relocating into other areas according to Fratkin et al., (2004). Majority elderly Rendille community members accept that, the Rendille herding range was minimized from 57,600 square kilometres to about 8,000 square km. while the human population expanded from about 8,000 to 25,000 between 1960 and 2000, resulting in high vulnerability to drought notes Fratkin et al., (2004). Vulnerability to drought is dependent on communities' abilities to mitigate the drought. Severe climatic conditions in the arid and semi-arid regions of the nation which are associated with low rainfall and variable rain patterns, has been identified as a significant contributor towards influencing crop and livestock according to FAO, (2004). Drought has in effect enhanced the susceptibility of the local community in Laisamis notes GOK, (2008). Drought is a common phenomenon in the study area which has been accepted by the communities notes Fratkin et al., (2004).

Pastoralists and subsistence farmers in the study area are much more prone to drought and it is tough for them to cope since persistent droughts and absence of modern-day intervention through innovative technologies are limited. For that reason, there is need to enhance

application of growing scientific knowledge to boost the flexible capabilities of pastoralists to mitigate drought argues Mirza, (2003). Regular conflicts and competitions have been observed between Rendille and Borana communities over water, livestock grazing and now farming on the mountain in Marsabit, which acts as fallback during severe droughts observes Fratkin et al., (2004). Rendille are in a difficult position of being surrounded by other competing pastoral groups including Boran, Gabra, Samburu, and Somali and find themselves in an increasingly restricted herding environment observes Fratkin et al, (2004), making them highly vulnerable to drought situation with limited grazing fallback during drought. According to Pavanello, (2009) in Lekapana, (2013), pastoral communities' vulnerability to drought is not only related to natural factors, but also to political, socio-economic and institutional constraints. This study considered some of these factors including natural and socio-economic dynamics which have been lacking from most previous studies.

Some common factors that determine drought vulnerability at household level include access to markets, market infrastructure, level of education, income levels and diversity, community social networks, access to credit facilities and access to extension services according to Opiyo et al., (2014). However, Notenbaert et al, (2013) did not consider these key factors in determining community drought vulnerability at household level. Though isolated research activities have been carried out, no comprehensive studies have been conducted in the study area to determine household drought vulnerability levels. The poorer households are the most at risk of adverse impacts of climate variability and change according to Stringer et al, (2009) in Opiyo et al., (2014). The authors do not differentiate between *risk* and *vulnerability*. The authors use the terms interchangeably, which should not be the case. Risk is mainly associated with capacity gaps, while vulnerability considers adaptive capacity gaps, exposure and sensitivity.

2.3 Adaptation options to drought in pastoral production systems

Although definition of adaptation is challenged by various scientists, it generally describes the development of genetic or behavioral qualities which enables microorganisms or systems to deal with ecological variations in order to thrive and reproduce explain Smith & Wandel, (2006). Drought adaptation within the framework of human livelihoods refers to activities or outcome in a system (household, community, team, market, region or nation) in order to much better deal with, handle danger, threat or opportunity notes Brooks, (2003). Ravindranath, (2012), in addition describes adaptation as change, flexible ability that is,. the capacity of a system to adjust with environmental changes and adjustments to potential challenges. Change entails longer-term modifications in sources of income, while coping entails temporary alteration in responses to transform or to minimize shocks along with anxieties on income sources add Eriksen et al., (2005) and Migosi et al., (2012).

Adaptation to drought differs between households and region based upon existing support systems that affected community livelihoods as explained by Brooks et al., (2005) in Opiyo et al., (2015). Other studies have exposed that pastoralists have an intimate connection with their environment and have rich knowledge that enables them to both secure and also utilize the changing rangelands adds McGahey et al., (2008) and Notenbaert et al., (2012). Comprehending how pastoralists adjust to severe weather conditions, especially long dry spell over sustained drought periods remains a subject that requires deeper research and understanding. Pastoralists globally encounter environmental, political, as well as socio-economic marginalization notes Schilling et al., (2012). This therefore implies that pastoralists need wide spread support on political and socio-economic spheres.

Various studies conducted globally mainly focus on choices of adaptations, but they rarely research the processes of adaptation where interventions are made, either with regard to environmental adjustments or policy options observes Smit, (2006). Worth nothing is the advancement of technologies and procedures applied in mainstreaming practical drought mitigation measures adds Smit, (2006). Numerous traditional flexible knowledge and income methods practiced around the world in ASALs for centuries are no longer adequate or efficient to support pastoral production systems describes Boko et al., (2007). Initiatives to decrease vulnerability of pastoralists communities should strengthen drought coping capacities by enhancing existing adaptation approaches and compliment them with choices that are appropriate to local contexts notes UNEP, (2009). Adaptation to drought is not accomplished in a single initiative. It is a continuum needing integrated approach that addresses drivers of drought vulnerability explains ODI, (2010). Adaptation to drought implies improving capacity for drought preparedness, mitigation and improving skills on drought early warning and drought early response activities.

In India and Syria, an Arab Facility for The Studies of Arid Areas and Dry Lands (ACSAD), has carried out significant studies on improving the productivity of rain-fed agriculture with focus on decreasing the unfavorable impacts of drought that have been occurring for a minimum of 2-3 decades. These initiatives include improving and introducing drought tolerant crop varieties, introduction of high breed certified seeds, soil conservation practices and water harvesting techniques observes Erian, (2010). In the United States, there has been substantial progress in addressing drought adaptation through preparation of readiness plans in various states notes Erian, (2010. However readiness plans need to be combined with response initiatives by improving drought monitoring and establishing an effective drought early warning and response systems.

Strategies including production of crops with short growth periods with less water requirements and establishments of food reserves to fulfill the emergency needs during droughts have been practiced in United States of America according to Erian, (2010). Along Mekong River in South East Asia, recurrent droughts have enabled farmers to grow crops requiring less rainfall and avoid growing of a second rice crop notes Miyan, (2014). Subsistence farmers have to exploit choices for innovative off-farm sources of income and adjust their livelihoods because crops including rice, coffee and sugar cane were not able to resist sustained drought conditions observed Orn-uma, (2010). The rainfall became limited in various parts of Bhutan and farmers begun converting paddy areas into dry farming fields notes Palden, (2011) in (Miyan, 2014). This is a major drought adaptation technique that has actually made it possible for farmers to engage in sustained food production even during long drought periods.

In Alxa Left Banner, Mongolia, herders utilized three indigenous grazing methodologies including seasonal mobility, long-distance movements and diversification of livestock species to minimize the impact of drought on communities explain Fan et al, (2013). Concentrating on the Yuanyang Balcony of South West, China, a popular agricultural area, shows that land use change, dynamic drought adaptation and Public-Private Partnership (PPP) are the major actions to reduce the drought calamity and have the crucial function in adjusting to droughts notes Yehong et alia., (2017). In the Least Developed Nations (LDCs) of Asia, droughts force communities to buy food by selling their lands, household goods and livestock at low prices observes Reardon et al., (1988). To adapt to drought, individuals either sell and or mortgage their land and livestock, as well as sell their possessions to acquire added cash inorder to mitigate the effects of droughts in Asia explains Miyan, (2014. During severe drought periods, communities resort to consumption of wild plants, bulbs, tubers and leaves not generally consumed during periods of abundance in Asia notes Miyan, (2014). Additionally,

communities practice farming modifications including irrigation and re-sowing, in order to compensate for the decrease in the plant area explain Brammer, (1987) in Miyan, (2014).

At the community level, friends, neighbours, relatives, influential and affluent members of the society may assist drought affected households through cash money, loans, food and clothing notes Paul, (1995). Beyond the local level, the nationwide government along with friends and loved ones of the drought impacted households that have employment and businesses outside the drought affected areas provide financial and other support to cope with difficulties of drought or famine notes Miyan, (2014. He adds that, free food distribution, clothing, medicine, and other drought alleviation items are provided by well-wishers and charitable organisations. Additionally, the government can reduce drought hardships by creating job opportunity for the drought affected especially for the youth and able adults through cash transfers via hunger safety net programmes.

A common practice is the use of techniques like fish farming, meat preservation, fruit drying, water storage in large reservoirs like in Ramsagar and Sagar Dighi in Bangladesh are some of the methods used by communities describes Miyan, (2014). Bangladesh Climate Change Strength Fund (BCCRF) has approved $153 million for jobs creation to fight negative influences of climatic that might enhance adaptation to drought explains Miyan, (2014). Despite various literature cited on drought adaptation options, limited studies have been conducted at global level with regards to pastoralists' livelihoods. There is a major gap on studies in pastoral areas globally.

Pastoralists have developed successful adaptation approaches to climatic variations in various parts of Africa for example, Borana of Southern Ethiopia have established deep wells and developed strong social structures which allows accessibility, usage and maintenance of these impressive structures during drought periods describes Menger and Ahmed, (2000). In dry

locations, including Namibia and Botswana, techniques such as livestock diversification consisting of nomadic pastoralism has been applied explain, CDKN, (2012). Reduced accessibility to water and forage resources through fencing off as well as privatization prevented this method from functioning properly explains, CDKN (2012). The concern is, what adaptation choices do pastoralists embrace in the light of more frequent and severe drought. The characteristics of changes taking place in the pastoral sector in Africa and elsewhere in the globe are inadequately understood or commonly neglected explains Menger et al., (2000).

Pastoralists use mobile livestock and nomadic systems characterized by long search for available pasture and water resources with erratic and unreliable rainfall patterns. In order to complement their livelihood to cope with drought, majority of pastoralists are venturing into agro-pastoralism and sedentarisation such as shop keeping around urban centres notes ODI, (2010). Mobility permits nomadic pastoralists to access pasture, water and salt licks enhancing their ability for better adaptation to various challenges of drought explain UNDP, (2007). Nevertheless, there are increased restrictions to herd mobility including socio-economic instability, climatic variations and environmental degradation observes Kaufmann, (2012).

Some elements of pastoral drought adaptation are frustrating and costly in the Arid as well as Semi-Arid Lands (ASALs) of Africa leading to politically instability and conflicts between pastoral communities and crop production farmers describes Menger et al., (2000). This has been observed in Marsabit and Laikipia. The challenges faced by pastoral societies are widespread. However, pastoralism still remains the main viable and efficient land use in the very arid and semi-arid parts of Africa where camel, cattle and goats production is practiced explain Ahmed and A.G.M., (2000).

The most viable drought adaptation alternative for Africa is to handle the effects of environmental changes related to drought. Restricted flexible ability to drought adaptation arises from inadequate access to financial resources, low technological capabilities and weak institutions that may conduct research notes Nkomo et al., (2006). The weak institution are usually poorly funded development partners. Trends in shifts away from crop and livestock production based livelihoods in rural areas explain that drought adaptation strategy is changing among the small-holders through diversification into other alternative sources that are nonclimate sensitive notes Newsham et al, (2011).

Pastoralism is undergoing a major transition in Africa as pastoralists exploit ways of integrating agriculture, urban employment opportunities and livestock production aimed at increasing meat and milk productivity notes Fratkin et al, (2004). In West Africa Pastoralists are not limited only to Arid and semi-arid lands, but have successfully expanded into the sub humid and humid zones of various countries with high mobility, extensive sedentarisation and capital intensive investments explains Catley et al., (2013). On the other hand, the pastoralists in other parts of Africa are not well integrated into the various production systems and the economy of the respective countries and therefore this implies weaker adaptation to drought.

According to Tambo et al., (2013), The main drought adaptation methods used in Nigeria include adjustments in planting time, use of drought resistant plant varieties, cultivation of early maturing crops and planting of livestock forage and fruit trees. The most usual ex-ante drought coping approaches of farmers in Sub-Saharan Africa include planting of drought tolerant crops, good agricultural practices like timely weeding and fertilizer application and water conservation, add Shiferaw et al., (2014). Shiferaw et al., (2014) further adds, depending on the severity of the impact of drought, households employ various coping methods including

reduction in food sales, minimized food intake on daily basis until drought eases out, defaulting on loans, increased rate of mobility to areas with adequate pasture and water, removal of children from schools and colleges, liquidation of productive household property including land, livestock and trees for timber production. Despite having these drought methods, farmers might still not have the ability to cope with extreme droughts or famine situations.

In a research study among the Maasai in Tanzania, livestock and household movements continue to be a vital coping system for pastoralists to prevent cattle loss during drought and these movements are currently occurring in a different ways that require not only substantial amount of investment but also expertise in livestock production beyond indigenous approaches, notes Goldman et al., (2013). Ajani et al., (2013) suggest that drought coping methods will consist of integration of reliable ecological monitoring methods, planting of drought escaping and early maturing crops and keeping of drought resistant livestock species in areas where below normal rains are received and drought have become more frequent and severe.

Farmers in sub-Saharan Africa are famous for preserving carbon in soils through zero tilling practices in cultivation, mulching and various other soil management methods, describes Ajani et al, (2013). Farmers have been recognized for practicing fallow system of cultivation, which motivated the growth of woodlands, add Ajani et al., (2013). Agro forestry is another technique that has been used for drought preparedness and mitigation in the long term. A practice similar to this has been defined in south western part of Nigeria to raise shade resistant crops such as Dioscorea spp and cocoyam in a permanent forest setting, explain Ajani et al, (2013). Similar practice may be adopted in the study area, though planting and conservation of economical indigenous plant species.

In Afar region, Ethiopia, Fenta et al (2018) revealed that agro-pastoral communities practiced irrigation farming in addition to livestock rearing, while pastoralists mainly concentrated on livestock as livelihood source and this scenario resulted in agro-pastoralist being more adapted to droughts implying that pastoralism is a risky investment area if not complimented by other livelihood sources. Muricho et al., (2019) revealed that, attendance of schools and colleges, access to credit and grant facilities, drought adaptive practices such as reducing post-harvest losses and use of plant material to feed livestock, establishment of grazing enclosures, introduction of improved livestock breeds, commercial honey production, traditional veterinary practices and afforestation had significant positive effects on building household drought resilience among the West Pokot communities. Communities in the study area have no diversified income sources to protect them against multi-dimensional drought effects, adds Muller, (2014). Therefore, there is need to direct more investments into pastoral areas in order to build sustained drought resilience and adaptation.

Improving farmers‘ decisions making through climate early warning systems, application of index based insurance and establishment of safety-net funds enables communities to cope with drought, explain Shiferaw et al., (2014). A research conducted in the Greater Horn of Africa by Omondi et al., (2013) confirms that recognizing the attributes of climate extremes such as drought at regional level is crucial not only for development of drought readiness plans and early warning system, but also in developing of drought adaptation methodologies.

The farmers in SSA have actually established intricate systems of gathering, prediction, analysis as well as decision-making in regard to weather and these systems of environment projections have been valuable to the farmers in managing their drought vulnerability and building resilience, explain Ajani et al., (2013). At commercial ranch level, a method of organic

farming is one of the most essential actions for adaptation to drought by farmers, note Ajani et al., (2013). Organic farming is a complementary agronomic practice which enhances agro-ecosystem health and wellness through prevention of nutrient loss, reduced water loss, provides soil cover to reduce wind and rain erosion making soils much resistant to floods, adds Ajani et al., (2013). Despite the various studies conducted in Africa on drought adaptation, there is a major gap on drought adaptation studies in pastoral production systems in Africa.

Socio-ecological systems changes in Borana rangelands have decreased drought adaptability among Borana pastoral production system. However, Borana pastoral households have not been easy targets; rather, they have shown considerable abilities to reply to the changing climatic variations through technological and institutional advancements, notes Tolera et al., (2019). Majority of Borana pastoral households were identified to have already embraced diverse nonpastoral economic activities such as crop farming to sustain their livelihoods. However, they are less likely to totally abandon pastoral ways of life due to climatic and physical limitation in the areas where they live, observes Tolera et al., (2019). Tolera et al., (2019) in a study in Southern Ethiopia, reveals that, the chance of pastoral families to utilize herd movements as an adaptive approach is dependent on livestock herd sizes, availability of manpower, conflict and political dynamics with neighbouring pastoral communities and access to pasture and water resources.

Mobile pastoralism has potential for slowing down environmental degradation, lowering poverty, stimulating economic growth and positively contributes towards development. However, as observed by the African Union, (2015), pastoralism has undergone transformation over generations in response to changes in rainfall patents, rising temperature levels, more frequent and severe droughts, urbanization and loss of grazing land to sedentary communities.

Interestingly, the size of livestock holdings determined the pastoral house's adaptation patterns, showing that livestock production still plays significant financial and socio-cultural roles in Borana pastoral contexts. Based upon these findings, it is suggested that pastoral actions such as long-standing mobility practice and existing herd diversities need to be backed by responsive institutional assistance.

Droughts are not new concepts in Kenya. For many years, pastoralists, farmers and agropastoralists have adjusted their livelihood sources and diversified due to rainfall scarcity during recurrent droughts. Nonetheless, the mix of unsustainable use, inadequate national as well as local policies, increased rates of environmental degradation have undermined the adaptive capabilities of pastoralists observe Schilling and Remling, (2011). In Kenya, social security networks exist among the nomadic pastoralists that made it possible for food and livestock to be redistributed during droughts. However, these are also breaking down with monetarisation of the community economy. In the absence of formal approaches like insurance coverage, the households experiencing losses during drought periods might use diverse non-insurance economic coping approaches such as livestock and financial loans in order to shield their assets as well as sources of incomes, adds CDKN, (2012).

Schilling and Remling, (2011) identified three ways of adapting to resource shortage as a result of frequent, prolonged and severe droughts among the Maasai of Kajiado, including extension of grazing areas, identify complimentary sources of income and moving of households to urban areas. Pastoralists move their livestock according to pasture and water availability and that the most drought adaptive feature of pastoralism is undoubtedly the tracking of seasonal rainstorms and grass production, an adaptation that directly mirrors wildlife migratory strategies in the savannas, indicates Western, (2002) However, the Maasai in Namanga reported that the

grazing area was too dry making expansion of the grazing areas necessary resulting in insecurity and conflicts with the neigbouring pastoralists, notes Schilling and Remling, (2011).

Recent initiatives such as fencing of large swaths of grazing land for oil exploration in Turkana has restricted herd mobility, which is a crucial drought coping strategy and therefore has undermined the pastoral system in the location, observes Opiyo et al., (2015). As an adaptation strategy, Kenyan Maasai have crossed the border into Tanzania exposing them to harassment and imprisonment by Tanzanian security forces, notes Schelling and Remling, (2011). Similarly, the recurrent droughts in Turkana, forced the Turkana pastoralists to migrate in and around Ilemi Triangle region in search of water and pasture for livestock, observe Mutu et al., (2017). However, these movements may result in conflicts with the neigbouring nomadic communities. This calls for peace building and conflict resolution mechanisms among the pastoral communities in order to access grazing and water resources during drought periods.

Herd splitting, rangeland monitoring, various livestock production methods including commercial ranching, group ranching, nomadic pastoralism and using wildlife as an indicator of forage availability, diversification into arable farming as well as employment are some adaptation strategies applied by Maasai in Kajiado indicates Western, (2002). Similarly, in Turkana, livestock owners subdivide herds and move them to places where forage and resources are available, note Fratkin et al., (2004).

Diversity of income sources, ability of livestock to track forage and water sources, diversification of herd make-up to take advantage of the varied drought conditions, diversification of livestock species and types, sending out kids to college for formal education to acquire specific skills are some of the long-term adaptation approaches used by Turkana,

describes Opiyo et al., (2015). Researches in Turkana reveal that drought presents significant obstacles for populations whose incomes depend mainly on natural resources like pastoralists, describe Below et al., (2010), Nicholson, (2014) and Opiyo et al., (2015). Livelihood diversity has actually not been given top priority as drought coping strategy in Kenya, according to GOK, (2008). In order to deal with drought threat in ASALs, hazard mitigation and prevention measures to reduction of vulnerabilities and drought adaptation capacities need to be enhanced.

Turkana people are involved in non-drought sensitive activities including micro businesses, manual labour daily jobs, artisan activities, formal employment as well as charcoal production, explain, Opiyo et al., (2015). Other livelihood support activities by Turkana community include harvesting of wild fruits for food and medicinal needs, traditional bee keeping, making baskets, mats and brooms from doom palm, describes Opiyo et al., (2015). There are numerous instruments for drought readiness such as insurance and savings, support from grants and loans, hunger safety schemes supported by Government of Kenya and other development partners applied in Kenya, report DI, (2017). Aggressive mobilization of resources, recognized long and short-term dangers to prevent an approaching disaster from happening in the first place or from escalating once causes have been identified has been applied in Kenya, according to DI, (2017).

Other drought adaptation strategies applied in Kenya include prioritized water for livestock and integrated into domestic water projects development, note Mutu et al., (2017). If this is not done, then conflicts over access to water may result in violence leading to human deaths. Proactive mobilisation of resources in response to identified long and short-term risks to prevent an impending disaster from occurring has been applied in Kenya, according to DI, (2017). In Maasailand and Samburu areas, who are both Maa language speaking, setting up wildlife conservancies through collaboration between landowners, Government of Kenya and

private sector active in tourism can be considered as an Ecosystem Based Adaptation (EBA) which involves conservancies management and rangelands conservation to enhance both wildlife tourism and pastoral livelihoods, describes Osano et al., (2013). Similar wildlife conservancies have been established in Laikipia, Isiolo and Marsabit Counties through efforts of private investors. Despite all the efforts made in adaptation to drought, many parts of the country suffer due to gaps in documentation and information sharing on various strategies applied in various parts of the country.

External undermining by development agencies by creating reliance on relief supplies for drought strategies by Pastoralists in Marsabit has triggered them to look for options outside the county, notes Oba and Lusigi, (1987). Reduced food usage, livestock businesses, mobility of communities were some approaches applied by households in Moyale and North-Horr SubCounties, according to VSF, (2011). Livestock movements were used by majority of pastoralists in the county, some relocating as far as Southern Ethiopia looking for water and pasture, observes VSF, (2011). In addition, some pastoral communities are engaged in income diversification initiatives consisting of honey production and charcoal trading in Ngurunet, Marsabit County and Loiyangalani in Turkana County, observes ALRMP, (2011).

Rendille in the research study location maintain a specialized tiny camel numbers adapted to their ASAL environment, although just recently they have actually begun to acquire more livestock from Ariaal community, their next-door neighbours and relatives, notes Fratkin et al., (2004). Herders practice numerous techniques targeted at maintaining their herds‘ efficiency during both abundant rainfall and dry periods to manage severe and mild droughts. Ariaal community apply herd movements and livestock species diversification as key strategies for drought management, notes Fratkin et al, (2004). Pastoral communities in Marsabit County

have utilized a variety of coping and adaptation techniques to deal with droughts including water trucking, distribution of emergency food and medical supplies.

Reduced food consumption by households, enhanced livestock trade and movements to trading centres are some approached used by Moyale, North-Horr and Maikona pastoralists following 2011 drought, report VSF, (2011. Livestock mobility was employed by many pastoralists in the region with movements to Southern Ethiopia in search of pasture and water, explain VSF, (2011). Additionally, some pastoral communities engaged in income diversity initiatives including fishing among the Turkana of Loiyangalani, notes ALRMP, (2011) in Lekapana, (2013). Despite some interventions on drought adaptation by development organisations, the pastoral communities have diversified in other non-livestock livelihoods including charcoal burning that are negatively contributing to environment management that may lead to extinction of some rare indigenous plant species.

The concept of nomadic pastoralism is considered a means of coping with as well as managing the natural resources. This is made possible via capacity of pastoralists to keep diverse livestock species including camels, cattle, sheep and goats, according to Oba and Lusigi, (1987). Pastoralists require huge herds and large land areas, not just to fulfill domestic requirements, but also to support social alliances, friends and relatives, notes Oba & Lusigi, (1987). The Ariaal community has a strategy for managing drought through diversified food support system including livestock and non-livestock sources of income, note Fratkin et al., (2004).

Livelihood diversity by pastoralists as a form of drought adaptation is worth studying, notes Newsham, et. al., (2011). An essential attribute of pastoralists survival in the dry lands is the flexibility in mobility in order to identify areas with pasture and water. Movement is reliant on

eco-friendly factors, including physical terrain difference, rainfall amounts and distribution, location of rivers, pans, boreholes and other sources of water and presence of salt licks, notes Fratkin, (2004). In the past when grazing land was vast, human population much lower and droughts less frequent, pastoral communities responded to drought through movements, hunting and gathering, observes Fratkin, (2001).

Other drought management methods applied in Marsabit, were herd divisions as well as income diversification including engaging in formal professional employment, notes Fratkin, (2001), Barton et al., (2001) in Lekapana, (2013). Some individuals have gone into petty shop businesses, formal employment in county government offices and employment with nongovernmental organisations (NGOs), observes Lekapan, (2013). As a drought coping method, Ariaal diversify their livestock herds (keeping a mix of camels, cattle, goats and sheep), expand their financial options while still maintaining a wide network of kin, age-mates and good friends they can depend on for emergency support, adds Opiyo et al, (2014). Despite various studies conducted in the study area over long periods, recent studies on drought adaptation options are lacking. Drought adaptation strategies used by Rendille, Arieel and Samburu in the study area are not well researched and documented. There is need for comprehensive study in the study area with a view to documenting and sharing with the community, government and researchers nationally and globally. Adaptation to drought is an indicator of building resilience among the households.

2.4 Impacts of drought on Pastoral production systems

Drought is an external climatic shock with the prospect to negatively impact on livelihoods, explain Martin et al, (2014). High temperatures and wind speeds can exacerbate negative effects of dry spell, notes Byun and Wilhite, (1999) and Lekapana, (2013). There are various

natural as well as human elements that combine to reduce accessibility to water and pasture including reduced moisture, high temperature and high wind velocity, notes Lekapana, (2013). Water scarcities in arid areas, connected with dry spell, should be considered a relative as opposed to absolute challenge, expresses Osono et al, (2014). Drought is a slow on set hazard presenting difficulties in making exact prediction of either its onset or end, explain Opiyo et al., (2014).

Drought is among one of the most complex natural threats as it impacts more individuals than any other danger worldwide. According to EM/DAT information quoted on earth Catastrophe Record (2007), more than 2.63 million persons were affected by climatic calamities internationally during the period 1997-2006 including 41.82 percent who were negatively impacted by drought and a further 38.87 percent of them were affected during the year 2002, according to GDS, (2013). Throughout 1997 to 2006, hydro-metrological catastrophes triggered an approximated damage of US$ 66.8 billion and 4.62 percent can be attributed to drought. In Asia, 81.11 percent, Africa 26.69 percent, Americas 2.57 percent and Europe 0.14) percent are the frequency of drought globally, notes Globe Disaster Record, (2007). Since drought is an international phenomenon covering various countries across the globe, there is need to develop a global approach to mitigate and prepare for droughts.

Worldwide Dry Spell Information System (GDIS), ((2013), notes that, temporary worldwide dry spells stayed reasonably throughout the world in August 2013 impacting 44 million individuals, while dry spell reduced in North America, Africa as well as Europe. However, remained extensive in Australia, constant in South America and escalated in Asia. A worldwide dry spell map prepared by University College of London, (2015) indicates 258 million individuals were impacted worldwide by dry spell in last 36 months. The capability of many nations to manage dry spells is limited by lack of and adequate reliable information, weak

international networks and low technical institutional capabilities, explains Miyan, (2014). A Country like Syria is just starting to develop a drought tracking and administration procedures and establishments. However, existing surveillance and drought early warning systems are poorly developed, notes Erian, (2010).

A study by Delft, (1993) by National Drought Mitigation Centre (NDMC) in United States of America uses DMC guidance on impact and vulnerability assessments as ―risk assessment and management‖ planning model. Dry spell risk is assessed via ―an analysis of vulnerability to understand what people and sectors may be most affected by drought, why these impacts occur, and if these relationships are changing over time‖. This method recognizes other components of drought vulnerability but does not identify impact as a function of vulnerability. Impact is as a result of interaction between hazard exposure and sensitivity. The study combines impact and vulnerability assessment leading to overlaps in definition and lack of focus. In a study by Keller and Niyogi, (2014) in the U.S.A indicates that, 2012 drought in the U.S.A. greatly negatively impacted on the agricultural sector. With equivalent severity and wide spatial coverage of droughts of the 1930s, 1950s, and 1980s, the 2012 drought affected majority of U.S. A research by Miyan, (2014) applied Vegetation Healthy Index (VHI) to categorize the impact of drought in temperate nations for each winter months from 2000 till 2010 to highlight the seasonal drought spatial irregularity and classified drought as, Slight drought, Moderate Impact of drought or Severe Effect drought. There is need for proper and comprehensive assessment of drought impacts through, monitoring and establishment of effective and efficient systems globally.

Drought has impacted in different parts of the globe. For example, in Australian drought affected 19 million persons during the drought of 2002-2003 causing damaging wildfire and

loss of 23 million hectares of oriental rice, note Widawasky and O'Toole, (1990). As a result of severe droughts, there has been decrease in lowland rain-fed rice production in the Mekong area of Cambodia as well as Lao, notes Miyan, (2014). Droughts typically trigger mass migration, starvation and death, as well as critically impact on the resilience of a country, explains Miyan, (2014). In 1876 to 1878, a drought in China impacted 83 million persons, while a drought in America in 1579 was more severe and lasted greater than twenty years, notes Erian, (2010). Food scarcities because of drought and price increases aggravated the tensions that led to the ―Arab
Spring‖, according to Global Risk Record, (2014). If not controlled, the Arab Spring may expand to the remainder of Africa and globally and result in political unrests as well as economic depression.

Africa's contribution to climate variation is minimum and yet it is one of the hardest hit by negative impacts. Efforts must be made by the much more established nations who contribute the mass of the greenhouse gases responsible for the worldwide warming to lower their emissions to acceptable limits and supply funds and technological capability to make it possible for Africa to experience less impact of drought, notes Nkomo et al., (2006). It may not be possible to determine the contribution of the greenhouses at the research site level. However, initiatives that reduce or mitigate the impacts of drought need to be developed at global level.

As a result of droughts, movement of households towards the northwestern part of Syria as well as from Syrian steppe to metropolitan created a high pressure on the stability of community livelihoods, notes Erian and Nashawatii, (2010). The dry spell triggered a high drop-out rate in schools, families left in the location who cannot afford basic needs such as food and clothing and countless Syrian farming families have been forced to relocate to cities

trying to find different casual job after two years of drought, explains Erian, (2010). The worst recorded drought of 2011 in Afghanistan impacted 14 out of 34 provinces of the nation undermining the livelihoods of 2.6 million persons, describes Huffington Post, (2011).

Drought incorporated with conflict has resulted in displacements of persons that are living in very poor conditions in Afghanistan, notes Miyan, (2014). In a research in Chihuahuan Desert in U.S.A. drought had a damaging effect on the population and the dominant livestock forage species, observes Brown et al, (2016). In Brazil, a drought research by Paula et al. (2014) shows that drought of 2010-2013 in the North East of the country, has been among the worst in the past 100 years in terms of water shortages, destruction to crops, livestock deaths and loss of livestock weight for commercial livestock producers, notes Ceará, (2013. Drought caused lack of drinking water, drying up of wells, dams and streams resulting in the need to support of 880,000 local farmers through government social assistance programs, adds Ceara, (2013). The impacts of recent drought, as well as numerous previous droughts have shown negative impact on the economy and other socio-economic negative results including migration, more disease prevalence and increased malnutrition, explains Ceara, (2013). Despite the fact that drought has been reoccurring in the rangelands for more than120 years, little progress has been made in the effort to relieve its impact on herdsman and rangeland ecosystem globally, notes Brown et al., (2016). There is no evidence of studies on impact of drought on pastoral communities especially in the Horn of Africa region.

Frequent droughts in the Arid and Semi-Arid Lands of Africa have caused loss of livelihoods and assets, resulting in illness as well as livestock and human deaths. During the Sahelian drought of the early 1970s, 300,000 individuals and large number of livestock deaths were

reported, according to Cordaid, (2007). Over six decades considering from 1960s, Africa recorded drought frequency of 382 incidents impacting on 326 million individuals, notes Gautam, (2006). In Sub-Saharan Africa, drought directly impacts on livelihoods, human health services, food security and some rare cases resulted in destitution, observes Shiferaw et al., (2014). These might include efficiency loss in crops production, poor livestock rearing, inefficient management of rangelands and forests management, increased fire risks, decreased water levels in wells and boreholes, increased livestock and wildlife mortality, reduced prices and degraded biodiversity, adds Sheferaw et al., (2014). These impacts may finally present in the form of lower income for farmers, reduced volumes of crop production, raised food prices due to supply and demand market forces, increased unemployment, lowered tax payments to government authorities, increased conflicts, movements to other favourable areas, displacements, poor nutrition, scarcity of food and balanced diet, better conditions for disease epidemics, raised pests and parasites burden and land degradation through various forms of erosion, notes Shiferaw et al., (2014). In pastoral areas, throughout durations of drought, the communities experience food shortages and high prices of grains and pulses, which needs to be mitigated or subsidies provided by the governments and development organisations.

The incidence of drought during the period 1970-2006 made up 20 percent of the all-natural calamities that hit the continent and impacted over 80 percent of the population, reports UNISDR, (2008). Long term drought in African countries has seriously impacted on economic development, undermined nutrition and food security leading to starvation and loss of human life and conflicts. For instance, the 2006 incidence of drought in the Horn of Africa was specifically destructive with 18 million people in five countries struggling with food scarcities in Ethiopia, Eritrea, Djibouti, Somalia and Northern Eastern Kenya. Drought induced social-economic challenges include, displacements of communities, cross border movements in

search of pasture with potential to trigger international conflicts that occur frequently, for example, between Northern Uganda and South Sudan, North Eastern Uganda and North Western Kenya , describes GOK, (2008). Severe drought events have negatively affected wildlife in southern Africa and this call for a comprehensive intervention.

Kanvazina, (1981) reported that the drought of 1980 resulted in regeneration of invader plants and high wildlife death in Lengwe National forest, Malawi. Comparable impact of drought was observed in wildlife sanctuary in Botswana and South Africa, reports Walker et al., (1987). In Zimbabwe, Magadza, (1994) in Miyan, (2014) observed the same. One of the most long term and prevalent droughts in Africa took place in 1973 and 1984, when nearly all the African countries were impacted by drought and in 1992, all southerly African countries experienced severe food shortages, notes Erian, (2010). General information is available but ample thorough logical data is not easily available.

In 2010/2011 drought triggered migration in the Horn of Africa among pastoral communities in Kenya, Ethiopia and Somalia experiencing tremendous loss of animals and human lives, impacting on more than 13 million persons, reports ISDR, (2012). The Southern Nuba tribes in Southern Sudan are usually in conflict during droughts with Arad nomads forced towards their region due to severe droughts, reports Erian, (2010). Significant drought disasters have been occurring in Mauritania, Sudan and Comoros Islands, where between the years 1970-2009, approximated 38.09 million persons were impacted by drought, observes Abu, (2009). The high negative effects have actually been experienced in various parts of Africa for a number of years due to poor drought readiness plans and drought mitigation initiatives.

In northern Kenya, about 3 million pastoralists were affected by serious droughts of 2006 and 2008/2009, which have been increasing in regularity as well as severity, notes Howden, (2009)

and Lekapana, (2013). The 2000 drought emergency situation affected the Central, Eastern, Great Rift Valley, Coastline and North Eastern Provinces in Kenya resulting in 4.4 million people needing food as well as non-food aid support. The 2006 drought struck 37 out 78 districts of Kenya leaving a population of 3.5 million individuals in need of emergency food and medical supplies, adds GOK, (2008). The nation also identifies that losses from calamities such as drought, can cause high damage to communities and their economic infrastructure, notes GOK, (2008). Drought risk reduction measures need to be established at national and local levels.

Drought in Kenya, according to AU, (2010) impact adversely all fields of the economic sectors including crop and livestock production, increased incidences of human wildlife conflicts, livestock and loss of human lives. Speranza, (2010) and Africa Union, (2010) observed impacts of drought on nomadic pastoralists present in various parts of Kenya experienced water deficiency and pasture shortage for livestock, hunger and malnutrition among humans, livestock deaths, deterioration of livestock body condition and low livestock prices. Mutu et al., (2017) adds that, in Kenya, the drought vulnerable areas have expanded and now even drought occur more frequently and severely in high rainfall areas of the country, notes GoK, (2008). The intensity of drought have become more destructive impacting on large population and this therefore calls for proactive ways for drought preparedness and mitigation.

The most severe drought impacted Central, Eastern, Rift Valley, Coast and North Eastern districts, where 4.4 million persons required emergency food and medical supplies between 1999 and 2000. Other drought incidence affected 3.5 million individuals who needed emergency food relief throughout the 2004 – 2006 period, notes ASAL, (2005). In Northern Kenya, where the dryness is most pronounced, 28 significant droughts have been experienced

in the past 100 years, explain ILRI, (2016). The frequencies of droughts have increased as four of the significant 28 droughts occurred in the last few years, adds schilling et al., (2011). Between the period 19992001 drought in Kenya resulted in loss of over 2.3 million sheep and goats, 900,000 cattle and 14,000 camels valued at US$ 77.3 million, shows Wekesa et al., (2006). An evaluation executed by Oxfam for 2005 drought in northern Kenya, revealed that over 70 percent of the livestock had died due to starvation and lack of water as a result of the drought, observes Wekesa et al., (2006).

In Kajiado County of Kenya, Maasai pastoralists lost nearly 30 percent of their livestock population following the drought of 1960 – 1961 with estimated cattle loss valued of US $ 7 million, observe Oba and Lusigi, (1987). In response to cattle deaths due to drought in Kajiado, some Maasai families have begun keeping camels which is more drought tolerant than cattle, sheep and goats, notes ACTED, (2011). Similarly, in Turkana, losses of 80 percent sheep and goats, 40 percent of camels and cumulatively 90 percent of livestock loss was reported during 1979-1980 droughts, report Oba and Lusigi, (1987). Droughts caused reduced livestock productivity among the Maasai pastoralists of Narok, where mature cattle used to form 80-85 percent of the herd but currently, this has lowered to 50-60 percent, indicating reduced performance, observes RoK, (2011c). In addition, livestock throughout the drought have been vulnerable and attract livestock diseases such as tick-borne diseases, foot and mouth, lumpy skin disease, CCPP (contagious caprine pleuro pneumonia), CBPP (contagious bovine pleuro pneumonia), camel pox and anthrax leading to livestock deaths and due to poor disease resistance as a result of diminished pasture and water availability, notes Morton, (2005). Livestock deaths and livestock diseases were observed among pastoralists during prolonged drought in Mukogondo location in Laikipia pastoral area note Huho et al., (2010) and

Lekapana, (2013). There is reed to have sufficient data to warrant interventions on drought related livestock diseases.

Drought has been the source of conflicts among pastoral communities leading to physical violence, loss of human lives and negatively influences the economy and undermines food security and community livelihoods in Kenya, observe Herrero et al, (2010), Lobell and Burke, (2010), Oluoko-Odingo, (2010) in Schilling and Remling (2011). In northern Kenya where guns are readily available due to proximity to conflict countries including Somalai and Ethiopia, recent droughts have seen an upsurge in raiding, social disturbance and mass movements from rural areas to urban centres leading to neglect of crop and livestock production, forest reserves and water towers converted into settlement areas and setting up of IDP (Internally Displaced

Persons) camps taking up valuable pastoralists‘ grazing land, notes Western et al, (2004). In the more dry northern part of Kenya where farming is feasible only in isolated highlands, population growth and frequent droughts have caused competition for pasture and water, resulting in armed fighting, for example, between Turkana and Pokot, Boran and Gabra, Rendille and Gabra, Rendille and Borana, Turkana and Samburu, as well as Somali and Boran herders, observes Fratkin et al, (2004).

Droughts in Kenya have led to loss of human lives and livestock deaths in Northern Kenya, loss of crops and ground cover and precipitated both human to human as well as human to wildlife conflicts in the drought vulnerable areas of the country, observe GOK, (2008). The net effect of drought has been to take away resources from planned long-term development programs diverted to emergency situations for food assistance and this has resulted in stagnation in economic progress of the nation, observes GOK, (2008). Farmers in Kenya have

experienced much more constant crop failures, decreased yields and low calorie consumption resulting in declining degree of nourishment in the community. Impact of drought has resulted in widespread poverty among pastoralists in Kenya due to diminished drought coping mechanisms, notes GOK, (2008). With declining pasture throughout drought periods, wildlife numbers tend to reduce because of animal migration, in some cases across international boundaries and wildlife deaths and loss of biodiversity have been reported, notes GOK, (2008).

Drought interferes with local empowerment networks and the social safety networks that are built around loaning of livestock to friends and relatives, observes GoK, (2008). Droughts have undermined social services and community support networks among pastoralists in Kenya, observe Pereira and Cordery, (2009) and Lekapana, (2013). Pastoral communities are confronted with dynamics in trade that negatively influence their food buying power and reduced livestock prices, observes Lekapana, (2013).

According to a research study in Turkana by Mutu et al. (2017), suggests that, during drought there is a decline in forage production which does not satisfy growing numbers of livestock. Other challenges faced by pastoralists during drought include dwindling livestock numbers via deaths and sales, poor crop harvest due to rain failure, high costs of grains and lower livestock prices, adds Mutu et al, (2017. During drought periods, livestock numbers remain low, with the poor under pressure to sell off their livestock to sustain their families while the affluent households may have the ability to endure the drought, adds Mutu et al., (2017). The authors did not include the final stage of the effect of drought consisting of sustained dependency on external support, human and livestock deaths fatalities in worst case situation and communities resorting to being environmental refugees. The basic opinion is that the pastoral system of livestock production, because of frequent drought, can no longer support community

livelihoods with ever growing numbers of human population, reduced livestock numbers and shrinking grazing areas. Significant appeals have been heard and reported in the media throughout Kenya for interventions in 2011 as well as in 2017 on drought effects in Turkana Area and the most affected areas in the Region were in the Ilemi Triangular belt, observes Mutu et al (2017). There is need for long-term resilience interventions in such areas of the country.

The Rendille, Samburu and Ariaal pastoralists in the study area were previously highly mobile with their livestock maintaining efficient use of natural resources within their grazing zones. However, households have now become sedentary due to a number of socio-economic reasons since the 1960s, observes Fratkin, (2004). Settlements have sprung up, schools, hospitals and other infrastructure have been developed forcing communities to settle inorder to access these facilities, notes Kaufmann, (2012). Destitute pastoral population is emerging as a result of not practicing and adhering to the traditional livelihoods which are suitable in the dry environment that they live in, explain ODI, (2010).

Pastoral societies had apparently lost their ability to handle droughts, or were at least facing much lower thresholds to famine and destitution, observes Mange and Ahmed, (2000). The move to settle in the study area by Rendille and Samburu communities is prompted by many factors including loss of livestock during droughts and political insecurity from raids by neighbouring Gabra, Turkana, and Somali pastoralists during the 1980s and 1990s periods, adds Fratkin et al., (2004). Accustomed to receiving famine relief food during droughts of the 1970s and 1980s, many Rendille permanently moved to urban areas where they could access famine-relief supplies like Korr and Kargi, created largely by the Catholic Church, notes Fratkin et al., (2004).

Furthermore, reduction of pastoralists‘ purchasing power is one of the important economic impacts of recurrent droughts, notes Lekapana, (2013). Ariaal in the study area lost cattle to drought primarily due to starvation and pneumonia, while their camels were less impacted by drought with a loss of 30 percent of their immature stock to trypanosomiasis (from tsetse flies), tick-borne diseases, respiratory infection and other common diseases, explain Fratkin et al., (2004).

Drought is likely to trigger a disturbance in livestock rearing for both domestic and export markets by lowering of body weights and reducing meat quality, which implies lower incomes for pastoralists, notes Barton and Morton, (2001). The lowered body weights will result in poor access to international markets due to high standards set globally and lower revenue for governments in form of taxes, explain Barton and Morton, (2001 and Lekapana, (2013). Drought adversely impacts the pastoral communities due to decreased access to pasture and water resulting in livestock deaths, notes Morton, (2005). Drought related livestock deaths have been related to lack of water and pasture and malnutrition which negatively impacted about 70 percent of animals in majority of ASAL districts throughout the year 2011 drought, observes RoK, (2011c) and Lekapana, (2013). In majority of Marsabit County, droughts have caused livestock death and morbidity, depletion of water resources, less domestic food supplies, severe malnutrition of up to 32 percent and more frequent incidences of conflicts between communities, report ALRMP, (2011). These factors directly contribute towards drought vulnerability among households. Additionally, 2011 drought resulted in emaciated livestock hence decreasing their market price, observes VSF, (2011). In addition, throughout the very same period, food prices in the area increased substantially and is attributed to drought, adds VSF, (2011).

Pastoralists were worst hit by drought as compared with communities in high rainfall areas of Marsabit, because they comprise majority of the population that live in drought vulnerable parts of Marsabit County, observes Lekapana, (2013). Pastoralist are compelled to move, trekking across countries and counties trying to find pasture and water for their livestock throughout including durations of droughts and normal rainfall periods. Mobility enhances resilience that reduces upsurge in livestock numbers, enhances income levels and supports livelihoods, notes Lekapana, (2013). Different publications have discussed impacts of drought on pastoralists' income. However, majority of the studies were not comprehensive and lacked deeper understanding of pastoralists‘ production systems. Little information is nonetheless available on impact of drought on pastoralists in the study area. Severe negative impacts may result in undermining community livelihoods that may be difficult to recover and result in destitution if effective drought mitigation measures are not put in place.

2.5 Theoretical Framework

The theory that was used is that drought risk is exacerbated by vulnerability [exposure ans sensitivity) and adaptaion capacity. Drought vulnerability is described as the ―degree to which a system is exposed to injury, damage, or harm, according to IPCC, (2007). Further to the definition of vulnerability, the Intergovernmental Panel on Climate Change (IPCC, 2007) redefines vulnerability to climate change as "the extent to which a natural and social system is exposed to sustained damage from climate change. The main components of vulnerability include *exposure* and *sensitivity*. However, the IPCC (2007) expanded to include *adaptive capacity* by defining the concept as "the degree to which a system is exposed to, and unable to cope with, adverse effects of climate change, including climate variability and other extremes", explain Miller et al. (2013). This study was based on the definition of IPCC (2007).

Vulnerability is always context-dependent in the sense of vulnerable of what towards what. In this study, it is pastoral production systems vulnerability towards drought. A household is said to be vulnerable to drought if found that drought is the main threat to livelihoods, livestock, vegetation, livestock fodder and water resources. It also includes damage to productive infrastructure like water pans, boreholes and other water facilities, note Martin et al., (2014). There are different driving forces of drought vulnerability that dominate i.e. (i) resource consumer- interactions that cause oscillations within the herd size, adaptation stocking strategy and transhumant rotations a part of the grazing management, and (ii) the natural (non-extreme) rain variability that's inherent in dry lands, Martin et al., (2014). According to IPCC, (2007), drought vulnerability is a function of exposure, sensitivity and adaptation capability. Completely different areas present different vulnerabilities to drought even inside a narrowly geographic region. The Intergovernmental Panel on global climate change (2007) has provided operational definition for vulnerability. It emphasizes ways to cut back the impact (sensitivity and exposure) of drought and improve adaptation capability, Dressa et al., (2014). The following IPCC formula was adapted to measure vulnerability in the study areas: V = (AC) - (S + E) where V is Vulnerability, AC is Adaptive Capacity, S is sensitivity and E is exposure.

2.6 Conceptual Framework

Drought vulnerability varies from one region to a different because of numerous socio-economic, biophysical, and political and access to technologies. Thus, some households area vulnerable than others in a community. There is also distinction in vulnerability among individuals based on gender, age, education, attitude, socio-economic (e.g., religion, ethnicity, social networks), access to resources and power, political structures, financial diversification, infrastructural constraints, poor technology, lack of market access and capital, land size,

biophysical attributes and access to infrastructural and access to data sources. Households receive minimum support from the government and different development organizations.

Factors that contribute towards vulnerability of households in pastoral communities include livestock possession, access to credit, access to socio-economic networks, and access to drought early warning systems among different determinants. Drought vulnerability has been studied by sociologists like Gillard and author, (1999) and Carver et al., (1989) who showed that vulnerability to disaster and stress include a net cultural, social and psychological factors.

In the context of drought, vulnerability has completely different dimensions with the drought intensity (exposure) pastoralists are faced with as a key issue. Exposure combined with sensitivity leads to impact. Drought vulnerability is decided by deducting impact (exposure and sensitivity) from adaptive capability (IPCC 2001). Pastoralists‘ adaptive capability is additionally influential by how households address drought. Overall, pastoralists‘ vulnerability to drought is influeced by economic, socio-culture, psychological, technical and infrastructural factors. The major drivers of vulnerability including adaptive capacity, exposure and sensitivity, may differ based on geographic location of the globe. Different areas present different vulnerabilities to drought even inside a narrow geographic region.

Smit and Wandel, (2006) stressed that the ideas of sensitivity and exposure, as main elements of drought vulnerability. In this regard, it is thought that households identical agro-ecological region could also be exposed to the similar levels of climate variation like drought, notes Eakin et al., (2008). Households are associated with the broader community, which might considerably have an effect on the decision-making related to the use of productive resources of a selected family. Therefore, it's necessary to find the mechanisms of drought vulnerability

assessment and adaptation at the family level with relation to the broader cultural and socio-economic processes at the community level, notes, Yaro, (2006). At the family level, sensitivity is presented in livestock production (i.e., mixed or single livestock species, tenure security of land and access to grazing land) with livestock production as the main means of livelihood.

All factors are combined to assist within the second step of vulnerability assessment that is choosing the key factors that contribute to drought vulnerability. At the ultimate stage, vulnerability, drought impact and adaptation option will be established. Adaptation measures are going to be designated in a very manner on address those factors that have a control on vulnerability to drought and their causes. Such measures need to reflect in development plans, setting and resource management in post-disaster periods.

Shiferaw et al, (2014) concluded that a proactive approach that mixes promising institutional, technological and policy interventions to handle the risks within vulnerable African communities is a step forward towards the proper management of drought and climate variability. Importantly, the whole process of vulnerability assessment within the proposed framework shows that vulnerability serves as an intermediate step embedded within the process of understanding and of adaptation, and is not the focus of the analysis itself (Fig. 2.1)

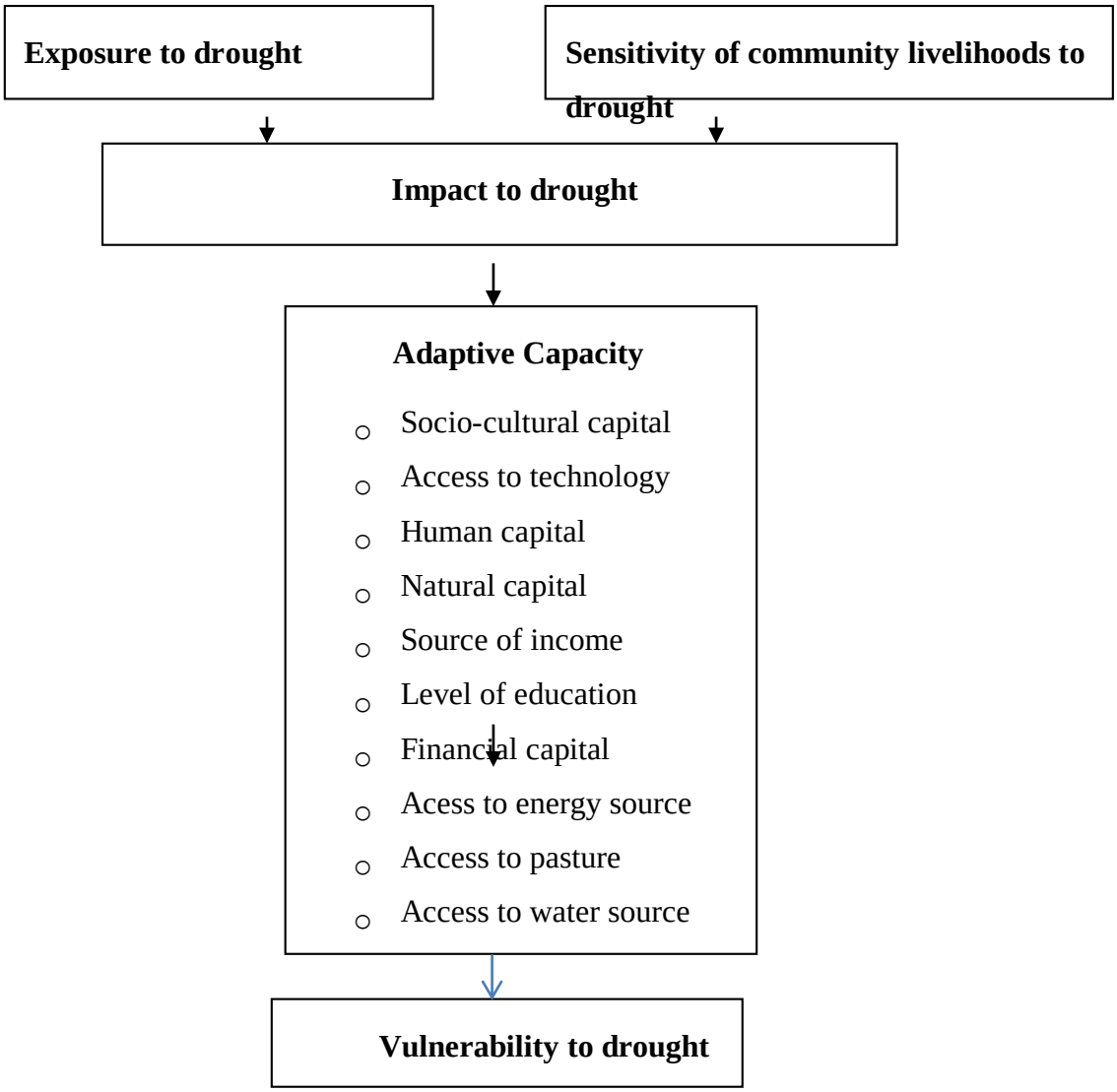

Figure 2.1: Conceptual Framework for Drought Vulnerability Assessment

Source: (self-developed)

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section describes the study area location, demographic and geophysical characteristics, research design, study population and sampling, data collection methods, primary data collection, secondary data collection, data analysis and results presentation, reliability, validity and research ethics.

3.2 Study Area

3.2.1 Location and Demographic Characteristics

Marsabit County borders Ethiopia to the North and North East, Wajir County to the East, Isiolo County to the South and South West and Turkana County to the North West and Sumburu County to the West (Figure 3.1). Marsabit is the largest county in the country covering 70,944 sq. km. with a population density of 6.481 persons per sq km. Marsabit County has a population of 459,785 persons with annual growth of 4.7 per cent, describes, Kenya Population Census, (2019). There are four parliamentary constituencies including Moyale, Sakuu, Laisamis and North Horr in the county (Figure 3.2). The study area covers the arid parts of Laisamis constituency, including four electoral Wards including Laisamis, Loglogo, Korr and Ngurunet (Figure 3.3). Laisamis Sub-County covers approximately 20,290 sq. km with an estimated population of 65,000 persons, describes Kenya National Burouw of Statistics (2019).

The study area, Laisamis, in Marsabit County is isolated and undeveloped compared to the rest of the country, where the major populations live in the central highlands in Sakuu Sub County. With low rainfall, seasonal rivers and no permanent rivers. Laisamis was chosen for the study

because it is the most arid part and relevant to the study because it is also prone to frequent droughs. Marsabit County is inhabited mainly by nomadic pastoralists, including Turkana, Samburu, Rendille, Borana, Gabra, and Somali, notes Fratkin et al., (2004). The poverty level was 83.2 per cent for Marsabit County observes NDMA, (2017). The county livelihoods include nomadic pastoralists, semi pastoralists, agro pastoralists, small businesses and employment. The main economic activity in Laisamis Constituency (the study area) is livestock rearing. The economy almost entirely revolves around livestock rearing including camels, cattle, sheep, goats and donkeys. Almost each household keeps livestock and other economic and social segments revolve around livestock production. The main livestock kept in the study area include camels, cattle, sheep and goats while crop production is only limited to few areas with shallow wells and micro-irrigation facilities. The study area is mainly inhabited by Rendille, Samburu and Ariaal communities, who are considered to be the most efficient producers of livestock under nomadic pastoralism. Few ethnic Somali community members practicing trade in food commodities and livestock are found in the trading centres including Korr, Loglogo, Ngurunet and Laisamis, Lekapana P.L (2013).

3.2.2 Geophysical Characteristics

3.2.2.1 Latitudes and Altitudes

Most of the study area is generally in extensive plains lying between 530-760 metres above sea level. Chalbi Desert, an old saline lake bed, lying at altitude of 435-500 metres above sea level is the lowest land surface in Marsabit County. The study area ranges from 1°20′N to 3°15′N latitude and from 36°30′E to 38°E longitude, spanning lowland with an elevation of nearly 500 m above sea level notes MCIDP, (2018). The Chalbi Desert marks the northern boundary of the study area, while Mt. Kulal (2355 m) marks the western boundary and the Ndoto Mountains (2885 m) and the Mathews Range (2688 m) mark the southwest boundary, GIZ, (2015).

3.2.2.2 Land Forms

The main landforms in the study area are sedimentary plains, volcanic plateaus, volcanic orgneissic ranges and hills. The rest of the study area consists of rocky, stony and rugged lava plains and sandy clay loams on alluvial plains and basement rock. The Chalbi area is completely devoid of plant life, due to its salinity, and in some other isolated areas the soils are too acidic to allow the growth of vegetation, MCIDP, (2018).

3.2.2.3 Climatic Conditions

Rainfall is unreliable and bi-modally distributed (theoretically) with two seasons per year, which is long rains in March-April and short rains October-November. Frequent rain failures occur leading to high risks of prolonged droughts. In Northern Kenya, droughts used to occur on average every five years but due to climatic variations, droughts occur more frequently and severely (MCIDP 2018). Most of the Rendille and Samburu population who the target of the study, live in the central lowland, which is known as the Kaisut Desert. The average high temperature in shade is 39°C and the average low temperature is 22°C, with little annual variation, notes Sun, (2005). The extensive daily sunshine leads to a great deal of global radiation and low humidity. Rainfall patterns in the lowlands are both low and unpredictable, with an annual rainfall averaging less than 200 mm per annum. The rainfall figures for the study Sub-County, Laisamis, range from 200 mm – 750 mm per annum. The rainfall is erratic and unreliable resulting in recurrent droughts and on rare occasion there are floods leading to livestock deaths and destruction of water infrastructure, GIZ (2015). This has increased the community‘s vulnerabilities towards drought and climate variations related hazards, exacerbated by high poverty levels, poorly developed infrastructure and socio-economic weakness among prevailing in the study area.

3.2.2.4 Ecological Zones

The study area comprises mainly of two ecological zones, that is, Ecological Zone V and VI. Zone V area fall between 700 metres and 1000 metres, and covers Kaisut and Milgis. The rest of the study area fall under Ecological Zone VI. The dominant vegetation consists of mixed acacia woodland on stony soils and acacia-commiphora bushland on deeper soils. The grass consists of tufted annual grass including *Cenchrus ciliaris* that is suitable for cattle and sheep. Grazing in this zone starts at the onset of the dry season and lasts for 3 to 7 months, during which time the livestock herds gradually prepare to move to the permanent watering points, observes MCIDP, (2018).

Ecological Zone VI covers areas lying below 700m above sea level. The annual grasses are poor and irregularly distributed. The high rate of evaporation and salt deposits inhibits the growth of grasses except saline tolerant species, particularly in Chalbi desert. The grazing season is short, lasting about two months after effective rains. When rains fail only camels and goats can graze in the area, notes Njoroge, (2010) to their browsing feed habits on tress and shrubs. About 30 per cent of the study area is not fully utilized due to lack of water and insecurity, slow land adjudication process, conflict between communal land use and private ownership and wildlife conservation further inhibit full exploitation of the remaining land, and these problems also constrain conservation measures, observes MCIDP, (2018). If these constraints could be addressed, more land would be available for both livestock and other economic activities. This could increase the overall study area livestock carrying capacity and reduce the rapid degradation of the fragile ecology in the study area.

The study area is characterised by wooded grassland, bushland and thicket, semi-desert grassland, and desert notes, Sun, (2005). *Acacia tortilis* is prominent in the upper strata, while

the middle strata are fairly clear of vegetation, and grasses dominate the lower strata. Cattle and small stock (goats and sheep) are herded in the high elevation areas, but camels rarely come to these places owing to the high humidity, altitude, abundance of harmful insects that transmit livestock and human disease, such as ticks, tse tse flies and mosquitoes. The bushland and thicket zone extends from an elevation of 600 to 1200 metres, and is found both at the foot of the mountains and in the lava area. *Acacia tortilis* and *Cordia sinensis* are conspicuous in the upper strata, while the lower strata are covered with shrubs such as *Sericocomopsis pallida* and *Duosperma eremophilum*. This vegetation zone covers approximately 40 percent of Rendille land, and is used by all species of livestock. Semi-desert grassland extends from an elevation of 400 to 600 metres above sea level, and covers most of the central lowland of Rendille land. Trees more than three metres high can be found only along the seasonal river beds. Thorny trees less than two metres high including, *Acacia* spp. and *Commiphora* spp. are scattered throughout the middle and upper strata. The lower strata include sandy lands covered by patches of bushes, herbs and shrubs, such as *Sericocomopsis pallida*, *Duosperma eremophilum*, *Indigofera spinosa* and *Blepharis linariifolia observe* MCIDP, (2018). This vegetation zone accounts for approximately 40 percent of Rendille land, and is mainly exploited by camels and small stock. More than 80 percent of Rendille land is used for livestock pasture observe NDMA, (2017). The vegetation species and quantities of plants are strongly influenced by topography and rainfall.

Plant ecology is important for the Rendille‘s livestock management strategies.

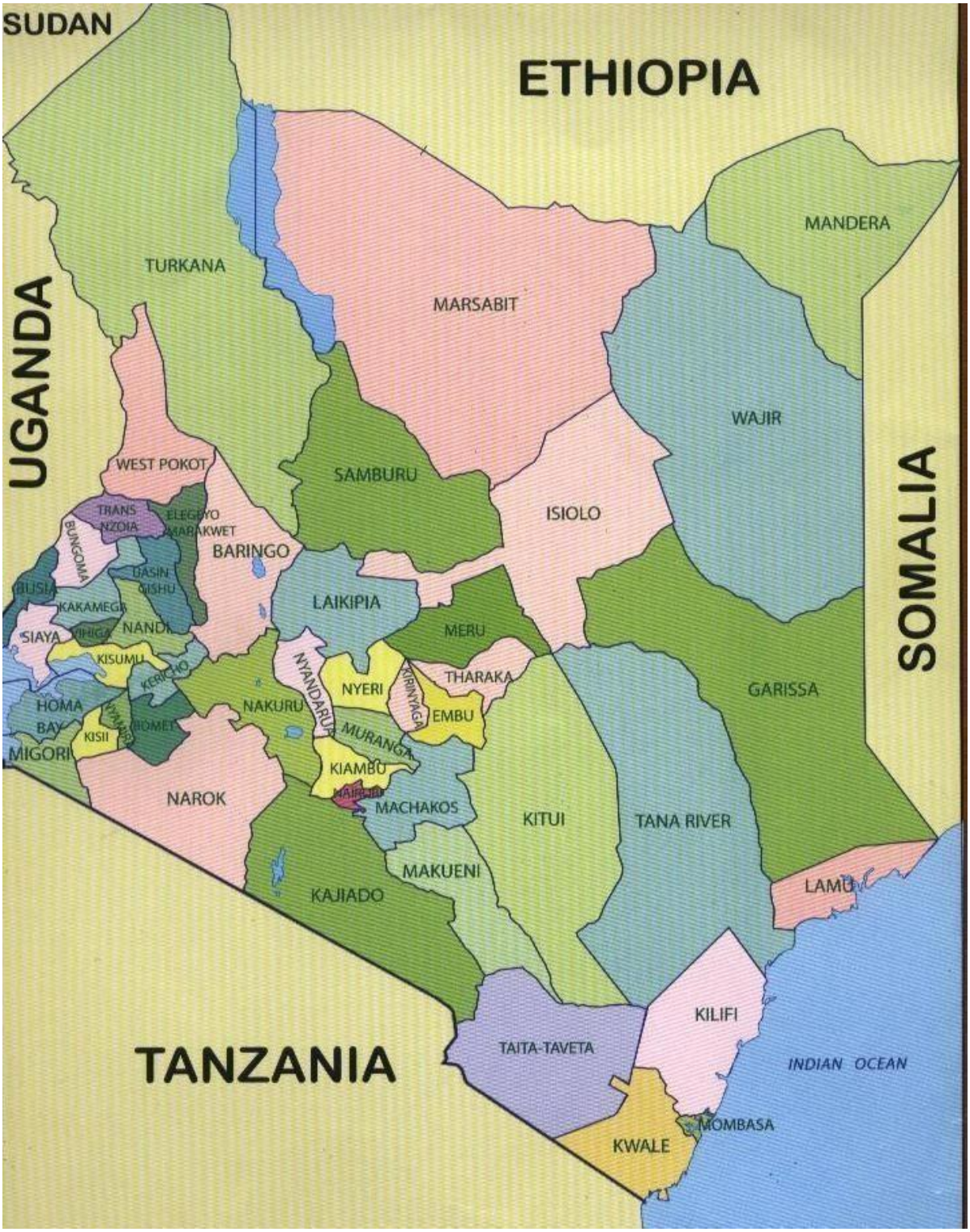

Figure 3.1 Map of Kenya showing Marsabit County

Source: Kenya Maps, 2012

The study area is in Marsabit as indicated in the next page

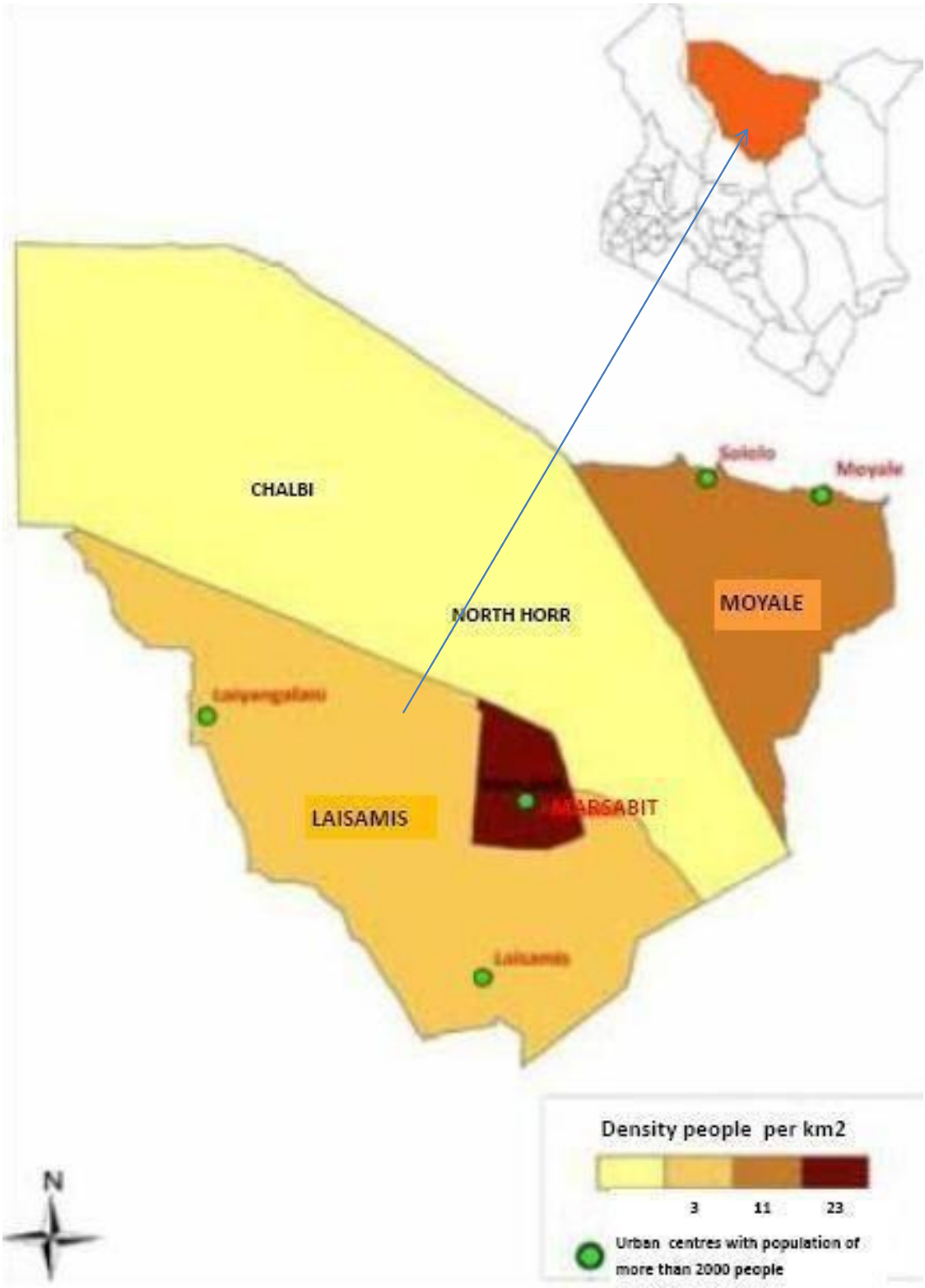

Figure 3.2 Marsabit County Map showing the location of Laisamis Sub-County

Source: Marsabit County Maps 2012

The study area is in Laisamis Sub-County as indicated in the map

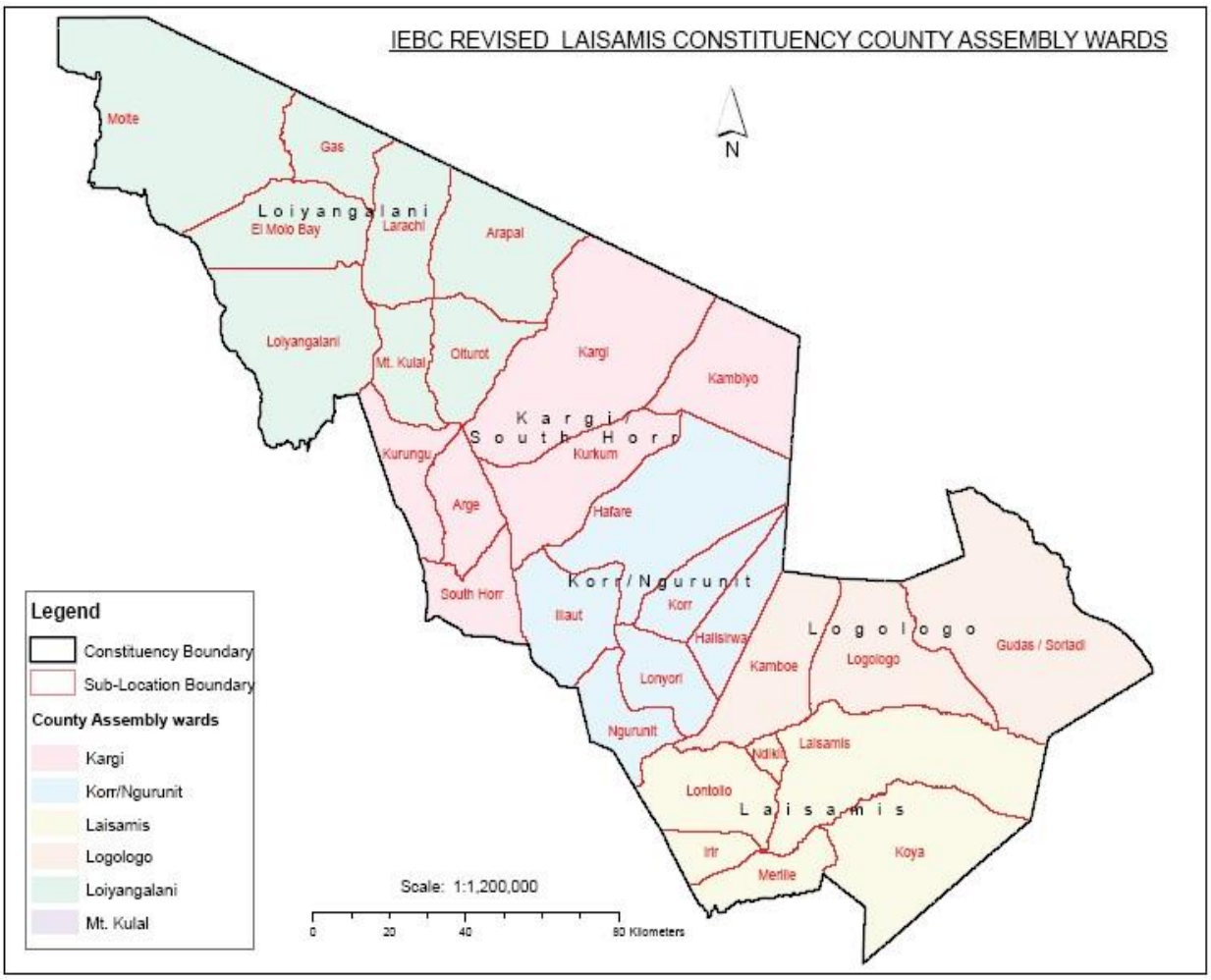

Figure 3.3 Detailed Map of the study area

Source: IEBC 2012

3.3 Research Design

The design used was cross-sectional and answers fundamental research questions including magnitude of drought vulnerability, impact of drought on households and identified drought adaptation options. The design provides systematic and accurate facts about households, the community, describes the current situation, what exists and the frequency of the variables, which is suitable to address the research questions of this study. Cross-sectional study was applied because it was the most suitable approach for the study, is relatively inexpensive takes

up less time to conduct, can estimate prevalence of interests because the sample is usually taken from the whole population and various variables can be observed at the same time. The cross-section approach of data collection was more appropriate for the study. Emeka, et al (2014) used cross-sectional survey study, using self-administered questionnaire which was conducted in two sections; demographics and self-medication attitude (in form of self-antibiotic use). A cross-sectional analysis provides estimates of the true model parameters but inferences regarding the significance of the explanatory variables, Bowen, et al (1999)The unit of analysis was the household because drought is directly related to household vulnerability, impact on household and adaptation decisions are made mainly at household levels. Nevertheless, households are connected to the wider community, which can greatly influence their decision-making processes in relation to use of particular productive resources, notes Opiyo et al. (2014). The total number of households in the study area were 6,182 and this was obtained from Kenya Population Census Report of 2019. 376 households were sampled and the sample size was arrived at through Taro Yamane (1967) simplified formula.

3.4 Study Population and Sampling

3.4.1 Study Population

The study covered four administrative locations including Ngurunet, Korr, Log Logo and Laisamis within Laisamis Sub-County, Marsabit County. The population for Ngurunet was 6,058, Korr, 9100, Laisamis, 6,424 and for Loglogo was 5,144 persons, according to Kenya Population Census, (2019). The household numbers were 1,665 for Ngurunet, 1,619 for Korr, 1,705 for Laisamis and 1,193 for Logologo, according to Kenya Population Census, (2009), (Table 3.1). 376 households were sampled through use of a questionnaire. One questionnaire was used with three different sections, that is, one section was for vulnerability assessment, second section was for adaptation question and the third was for impacts of drought assessment.

Proportional allocation of questionnaires was done depending on the size of the population of the village and households. Thus, in Ngurunet 101 households, Log Logo, 73 households, Korr, 101 households and in Laisamis 101 households were interviewed. The sampling was done systematically by skipping every five households in a transect walk through a village.

Table 3.1Ssmpling frame

Location	Population	Targeted Number of Households
Log Logo	5,144	1,193
Laisamis	6,424	1,705
Korr	9,100	1,619
Ngurunet	6,058	1,665
Totals	**26,726**	**6,182**

Source: (2019KNBS)

3.4.2 Sample Size

A sample is defined as a proportion of a population, note Zikmund et al., (2013). A sample is a subset of a population, describes Kothari, (2004). Here a sample refers to small percentage of a whole target population which a researcher is interested in, observes, Gog, (2015). Since the target population for this study was less than 10,000, the sample size was determined by using "Taro Yamane (1967) as indicated below.

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

Where:

n = sample size, ***N*** = population size.

e = the level of precision

1 = Constant

This formula assumes a degree of variability (i.e. proportion) of 0.5, the level of precision of 5% and a confidence level of 95%. Applying the formula to 6182 households, the sample size for the study was:

$n = 6182/ \{1+ 6182 (0.05)^2\}$

n = 376 households.

The sample size for the study was therefore 376 households as presented in Table 3.2.

Table 3.2 Sample Size

Location	Targeted Number of Households	Sample Size
Log Logo	1,193	73
Laisamis	1,705	104
Korr	1,619	98
Ngurunet	1,665	101
Totals	**6,182**	**376**

3.5 Data Collection Methods

3.5.1 Preparation for data collection

Initial survey of the study area was conducted five months prior to the beginning of the study to identify the possible areas for the study and prepare for working relationship with the leadership of the relevant communities. This initial survey enabled a better understanding of the peculiarities of the study area, size of the sample and identification of local enumerators for the household interview. 16 local enumerators were identified i.e. four enumerators for each of the four villages. The research assistants `1were given one-day training to minimize bias and errors in data collection and to familiarise the enumerators with the objectives of the study.

Pretesting of questionnaires was done on about 11 per cent of the samples size equivalent to thirty eight (38) households in Loglogo and the questions adjusted accordingly. This was in line with Kothari, (2009) who stated that the size of a sample to be used for piloting testing

varies depending on time, costs and practicality, but the same would tend to be 5-10 percent of the sample. It was done in Loglogo because of proximity to the main highway and the community is typical representation of the study area. The pretested questionnaires were not included in the final results analysis.

3.5.2 Primary and Secondary data collection

Data was collected over a three-month period from 1 st. March - 30 th. May 2015. Information on various aspects was collected through interviewing of the selected household head. The survey addressed information about household characteristics, household access to basic services, livelihood assets and their trends, income per household, sources of income, drought information, drought impacts, drought adaptation coping strategies, social networks and remittances. To avoid misunderstanding, the household interviews were undertaken in the local language by the local recruited research assistance.

Rainfall data was collected from the centres where available for the last 30-50 years. Rainfall data was obtained from Kenya Meteorological Service (KMS) weather stations, though some in Loglogo, Ngurunet and Loglogo were not manned. The rainfall figures what determine level of drought. The secondary data was collected from through reports from the Government of Kenya relevant offices and institutions, development agencies and relevant literature.

3.5.2.1 Drought Vulnerability Assessment

The study employed the approach of choosing the indicators to determine drought vulnerability of households. Having selected the appropriate vulnerability indicators, the values of the vulnerability indicators were used to make the indicator‘s value within 0 – 1 range of the vulnerability index., By subtracting the mean from the observed value and dividing by the

standard deviation for each indicator, the index figure is obtained. . The next step was to assign weights to the selected vulnerability indicators. In this study, the principal component analysis Principal Component Analysis (PCA) was employed to assign weights to the indicators, based on studies by Filmer and Pritchett, (2001). The vulnerability index of each household was calculated using the following equation developed by IPCC, (2012): V = AC – (E + S), where: V = the vulnerability index of each household, AC = the adaptive capacity index, E = the exposure index and S = the sensitivity index for the corresponding household.

3.5.2.2 Drought Impacts

A total of 376 households were interviewed for drought impacts on human, livestock, natural resources (water, vegetation and wildlife). The questions included, what are the drought impacts on humans based on age groups, that is, children under five, children 6 - 18 years, youth 19 - 35 years (according to Government of Kenya), adults 36 - 60 years and elderly and over 60 years old. Other questions were relate to drought impacts on various livestock species, drought impact on water sources, pasture availability, impacts on food availability, drought impacts on food prices, drought social impacts, drought impact on wildlife, drought impact on human to human conflicts and conflict between wildlife and human. Drought impacts were measured through Rainfall Index.

3.5.2.3 Drought Adaptation Options

A sample of 376 households were interviewed for the drought adaptation data with the same questionnaire which included adaptation questions for long-term adaptation options, the species of livestock kept, livestock species diversity, household mobility, livestock mobility, pasture preservation, grazing reserves, season grazing, employment, non-livestock sources of income, education levels, conflicts and peace building with neigbouring communities for

access to water and grazing sharing. The households were also interviewed on short-term drought coping methods.

3.5.3 Secondary data collection

Secondary data was collected from meteorological stations managed by Kenya Meteorological Services, Government of Kenya (GoK), technical reports, NGOs' reports and County Government reports. The secondary data collected include rainfall and temperature from the meteorological stations in the study area. Records on frequencies of droughts and floods were obtained from the relevant GOK authorities in the Sub-County. Rainfall data over 30 - 50 years was collected where possible. The data sets obtained include mean monthly rainfall averages together with minimum and maximum temperatures. However, there were some missing rainfall data for some centres in the study area including Korr, Ngurunet, Loglogo and Laisamis due to lack of manned weather stations. Trends in rainfall deviations were recorded. Additional secondary data were obtained from existing literature including published reports and other relevant sources.

3.6 Data analysis and Results presentation

3.6.1 Quantitative and Qualitative Data Analysis

Primary data obtained were analysed through SPSS Version 20 and MS Excel programmes. Drought Vulnerability data including exposure, sensitivity and adaptive capacity was analysed through SPSS were weighed codes were assigned to each variable within exposure, sensitivity and adaptive capacity. The maximum weight was 1, while the minimum was 0. Vulnerability Index was analysed by combining the mean of sensitivity and exposure and deducting from the adaptive capacity. The Adaption options was analysed through obtaining the percentages of how each household responded to each option for adaptation. For impact on drought, the percentage of how households responded was obtained based on the impacts on humans,

livestock, natural resources and contribution of drought to conflicts and insecurities. Data on rainfall and temperature were analysed from the study area over 10 – 50-year period depending on data availability from the various trading centres. The rainfall and temperature data was useful in providing indications of drought years in the study area over a long period of time.

3.7 Reliability and Validity of Data

For investigating the validity of questionnaire, diverse methods such as translation validity from English to local languages is necessary, as observed by Glolami et al., (2012). The translation validity of the questionnaire was investigated through pretesting. This step was done with a particular sensitivity in order to avoid any problem in transition stage of questionnaire. Appropriate sample size was used for consistency. To improve reliability and validity, one questionnaire was used for data collection but with three different sections addressing each specific objective. The questionnaire were pretested for reliability and checking clarity of questions. No major issues were observed during the pretesting. Other tools for data collection including observations, photographs, and climatic data from meteorological stations managed by Kenya Meteorological Service are considered reliable. Methods used by other researchers were also compared to confirm reliability of the tools used in this study.

The primary data questionnaire and secondary data were checked for completeness and cleaned before final entry into computer for analysis. Field notes made during administration of questionnaires were organised into themes in line with the study objectives and checked after primary and secondary data collection.

For this study, reliability was calculated using Cronbach_s alpha formula and results generated with the aid of SPSS version 26.0 , Cronbach,(2018)Reliability test results are presented in Table 3.3.

Table 3.3: Reliability Analysis

Variable	Number of Items	α>0.7	Comment
Vulnerability to Drought	18	0.888	Reliable
Adaptation Options	11	0.812	Reliable
Pastoral Production Systems	19	0.715	Reliable

The findings in Table 3.3 show that Cronbach's alpha for all the items were above 0.7 i.e Vulnerability to Drought [0.888], Adaptation Options [0.812] and Pastoral Production Systems [0.715] indicating that the questionnaire was adequately reliable for measurement and suitable for data collection. Since the variables measured had Cronbach's alpha above 0.7, they were thus acceptable and reliable means of data collection. Additionally, Taherdoost, (2016) provide the following rules of thumb: >0.9 – Excellent, >0.8 – Good, >0.7 – Acceptable, >0.6 – Questionable, >0.5 – Poor and <0.5 – Unacceptable. The findings indicated that the Cronbach alpha for each of the variables was above the lower limit of acceptability thus reliable.

For validity testing, this study used both construct validity and content validity; for construct validity, the questionnaire was subdivided into several sections to ensure that each section assesses information for a specific objective. This was also to ensure that the information being assessed closely ties to the conceptual framework for this study. Kaiser-Meyer-Olkin (KMO) was used to determine whether the responses generated were valid based on their values. For a data set to be regarded as valid and appropriate for statistical analysis, the value of KMO should be greater than .5 notes Field, (2013). The results of the KMO and Bartlett's Test of Sphericity (significance) are summarized in Table 3.4.

Table 3.4: Validity Test

Variable	KMO	Significance
Vulnerability to Drought	.797	.000
Adaptation Options	.671	.000
Pastoral Production Systems	.821	.000

Findings in Table 3.4 show that the KMO statistic for all the variables were greater than .5 which was significantly high, that is greater than the critical level of significance of the test which was set at .5 by Field, (2013). In addition to the KMO test, the Bartlett's Test of Sphericity was also significant (.000, at $p < .05$) for all the study variables. These results provided an outstanding validation for further statistical analysis to be conducted on the study variables.

3.8 Research Ethics

During the research process, all materials and research information, tools and literature were acknowledged and cited. Interviews with households were accepted by the leadership of the target communities. The area Chiefs were consulted and permission sought to conduct the interviews. The researcher was cleared by the local authorities to visit households and conduct interviews in the study area. Having worked among the target community before, the researcher is familiar with the cultural and socio-economic dynamics in the area. Authorisation and clearance was sought from spouses before conducting the interviews. Appropriate time and place for interviews were determined and agreed upon between the enumerator and the respondent. For materials that require permission to use, the necessary authorisation was sought. Authorisation to conduct the study was obtained from the National Research Council (copy of the letter -appendix 2 and 3).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter includes results of findings and discussions. Social-demographic information of the study area. This section provides answers to the research questions, that is, what is the magnitude of vulnerability to drought in pastoral production systems? What are the adaptation options in the pastoral systems? What are the impacts of drought in pastoral production systems? Description, analysis and synthesis of the findings were discussed in this section. Discussions on pattern of findings and comparisons with other literature were done. This section includes discussions and findings on socio demographic information of the study area, magnitude of vulnerabilities to drought in pastoral production systems, adaptation options to drought and impact of drought on pastoral productions systems.

4.2 Socio-demographic characteristics of the respondents

A total of 376 households were interviewed and the distribution is, 27.7% (n=104) were from Laisamis Centre, 19.4 % (n=73) from Loglogo, 26.1% (n=98) were from Korr and finally 26.9% (n=101) were from Ngurnet (Figure 4.1). The percentages and numbers indicate the households interviewed out of the total 376 per enumeration area.

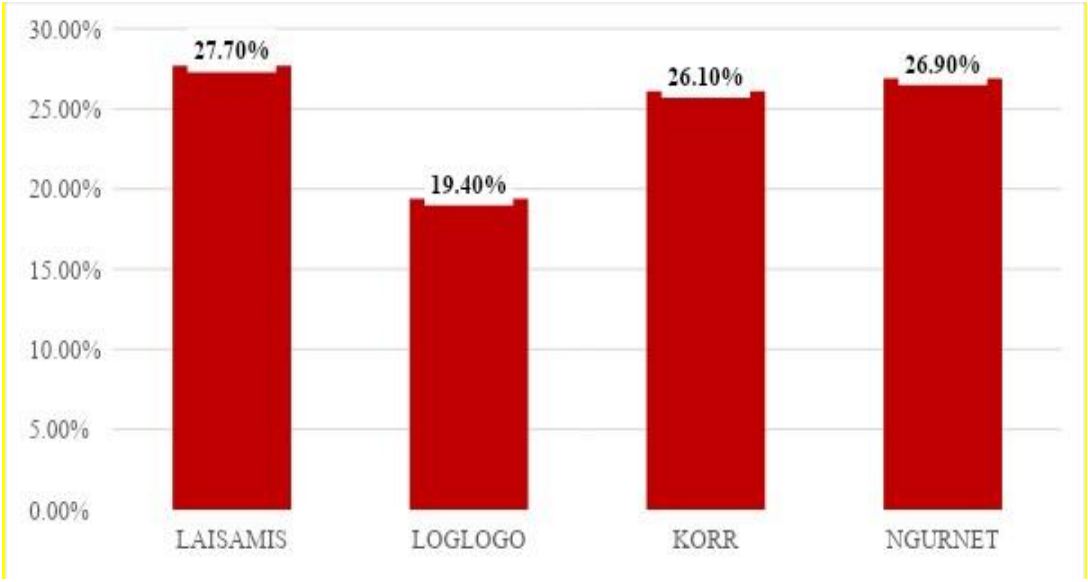

Figure 4.1: Enumeration proportions in the study area

In Ngurunet 82.5 percent of the respondents were female while 17.5 percent were male. In Korr 86.8 percent were female while 13.2 per cent were male. In Loglogo 97.8 percent were female while 2.2 percent were male. In Laisamis, 73.1 percent of respondents were female while 26.9 percent were males. In the study area, 85 percent of household respondents were females while 15 percent of the household respondents were males. The percentages and numbers of households interviewed and gender representation is indicated in figure 4.2. The gender distribution does not necessarily represent the head of household, rather it represents the gender of the household who was available to be interviewed. However, in some cases, the female gender was heads of households due to lost spouses on absent spouses who have gone to towns to seek employment because the study area was under drought and shortage of resources condition.

The reason why the numbers of respondents were high for females is because they were available during the interview, while male members of the household were either in the urban centres to engage in casual paid labour or are in distant places with livestock in satellite grazing

areas. Interview timing by enumerators also contributed to large females being interviewed because of their availability between 10.00 am – 12.00 noon. The males are usually not readily available at these times of the day. The males usually returned home late from 5.00 pm – 7.00 pm, which is not appropriate to visit homes for ethical and cultural reasons.

4.2.1 Distribution by gender and age

Figure 4.2 shows the distribution by gender of the various households in the four enumeration areas including Ngurunet, Korr, Loglogo and Laisamis. In Ngurunet, 82.5 percent of respondents were women while men represented 17.5 percent. In Korr 86.8 percent were women, while men respondents were 13.2 percent. In Log Logo, 97.8 percent of respondents were women while men were 2.2 percent. In Laisamis, female respondents were 73.1 percent while men respondents were 26.9 percent as shown in Table 4.1. The percentages of female respondents were higher because, the survey was conducted in a drought season and majority of men took livestock to satellite camps to access pasture and water, while some had gone to urban centres such as Marsabit Town, Isiolo and Nairobi in search of casual work to support their families during the drought.

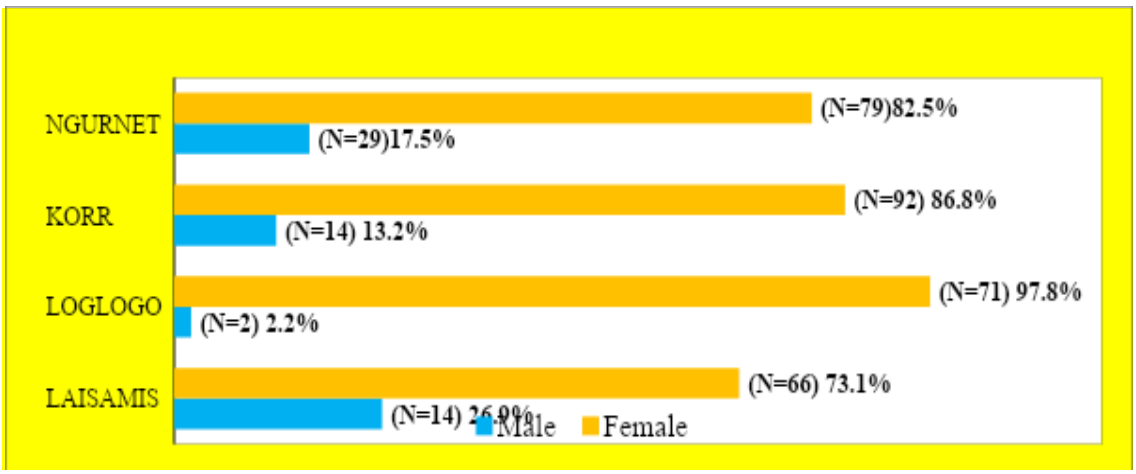

Figure 4.2: Distribution by gender in the study area.

The N is repsenting % for every trading centre.

Table 4.1 Males and females headed households

Enumeration area	Male Headed households	Female headed households	Total
Laisamis	28	76	104
Loglogo	2	71	73
Korr	13	85	98
Ngurunet	18	83	101

As shown in figure 4.3, the largest group from all the enumeration areas is between ages 36-60 years with the least being the age groups above 61 years. The age group of 36–60 years is the most active and productive age among the respondents. Categories in age group above 61 are more vulnerable because they have no adequate energy to engage in economic activities. For knowledge and historical facts, ages 36 - over 61 are important. The household with under 2 members is the largest, with under 5 years (43.2%), with 6-18 years (29.9%), with 19-64 years (52.3%), with those above 65 years is (55.3%) with the highest of size.

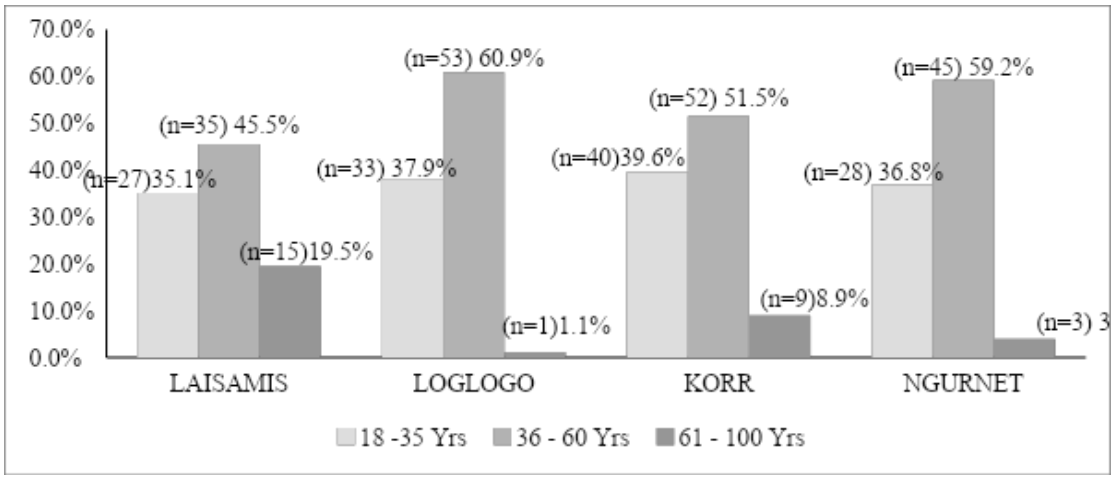

Figure 4.3 Age distribution in the study area

Female headed households with highest number of members in Laisamis was 2 at 24 percent, in Loglogo is 3 members at 28.9 percent, in Korr with 3 members at 34 percent, while in Ngurunet, households with 2 members was 26.3 percent. Female headed households with 11 members had lowest frequency in Laisamis. In Loglogo female headed households with 6 members was least frequent at 1.1 percent. While in Korr, female headed household with 7 members was less frequent at 0.9 percent. In Ngurunet, female headed household with 5 members was the least frequent at 11.3 percent.

The assumption is that, households with more dependents are more vulnerable than households with fewer dependents. The existence of the dependents may enable the provider, such as a parent or guardian, to claim more support from government or development partners during emergency drought relief food supplies. However, in a pastoral set up, the dependents rely on individual household heads to provide food, shelter and other basic services, resulting in pressure on the household head. In consistent with the study findings, Opiyo et al. (2014) found out that in Turkana, the determinants of households' vulnerability were significantly influenced by size of the household, number of dependents, household head, marital status and other social linkages. The results of the study show that households with more members were more vulnerable to drought. The results are also consistent with previous findings by Kakota et al., (2011) and Gebrehiwot and vander Veen, (2013) that household large numbers lead to increased vulnerability to drought. The household size distribution for the study area is shown in Table 4.2.

Table 4.2: Laisamis Sub-County by size of households

Household members	1	2	3	4	5	6	7	8	11	13	
% Males	12	25	27.9	18	8.6	3.9	2.4	1.6	0	0.6	**100**
%Females	13.5	23.2	26.6	19.5	11.4	4.5	0.8	0	0.5	0	**100**

From Table 4.2, male headed households with 2 dependents were 25 per cent of respondents, while those with 3 dependents and above were 75 percent. For female headed households, the households with 2 dependents were 23.2 percent, while those with 3 dependents and above were 76.8 percent for the study area.

In Laisamis Sub-County, the numbers of dependents are presented in Table 4.3 according to the size of the households and age groups. The vertical part of the table indicates percentages of each age group in the households, while the horizontal part of the table shows the number of members in each household. According to the data, the household with 2 members dominate, followed by households with 1 member. Households with 3 to 4 members are moderate, while households with 5 – 16 members are rare (Figure 4.5). Members with two members are at times husband and wife only or a widowed lady with a child and some cases a widower with 1 child.

Table 4.3: Size of household by age groups in Laisamis Sub-County

Household members	1	2	3	4	5	6	7	8	9	16	
Under 5 years	42.4	43.2	12.8	1.6	-	-	-	-	-	-	**100**
6 – 18 years	12.8	29.9	27.4	14.3	9.3	4.4	0.9	1.0	-	-	**100**
19 – 64 years	11.3	52.3	13.1	10.1	4.3	3.4	2.4	2.1	0.6	0.4	**100**
Above 65 years %	55.3	42.1	-	-	-	2.6	-	-	-	-	**100**

High percentages of women in the study area were single mothers or widowed. The female headed households or widowed households are likely to be more vulnerable to drought and related stresses due to reduced incomes from the spouses. This is consistent with a study by Opiyo et al., (2014) and Tesso et al., (2012) conducted in Turkana County. The study has shown that female-headed households, divorced and widowed persons‘ households with experience of less than 5 years in the area, are likely to be affected negatively by climate stresses and variability such as drought, notes Opiyo et al., (2014). However, Muricho et al., (2019) observed that male-headed households were less resilient compared to female-headed households. This contradicts previous studies by Opiyo et al., (2014) and Tesso et al., (2012), which found that female-headed households were less resilient largely due to bias in resource allocation and decision making that leans towards males in most pastoral communities. IIRR and CTA (2012) observed that there is emerging trend among pastoral communities where women are increasingly taking charge of managing livestock enterprises such as poultry, thereby putting them in a position to build their resilience at times better than men. The same observation was made in the study.

During climate stresses and shocks like drought, these categories of households tend to have fewer options of making a living because of a combination of various factors including low employment opportunities due to low levels of literacy. Similarly, female or divorced and widowed household heads are likely not to be empowered enough in pastoral communities to make household decisions and are frequently without access to credit services and adequate capital assets or not able to own large herds of livestock to manage households‘ daily requirements, notes Nabikolo et al., (2012). Similar observations have been made by Kakota et al., (2011) in Malawi and Tesso et al., (2012) in Ethiopia.

Women play significant role in the household decision making among the pastoralists. There were 82 - 98 percent women respondents in the four enumeration areas. The study communities comprise 52.3 percent of 19 - 64 age groups, which is the most economically productive group. This implies that the community has adequate human resources to engage in economic activities. For example, households with more productive categories are less vulnerable than the categories with less productive ones. Less productive categories are more likely to be vulnerable compared with the productive category explain Opiyo et al., (2014). Elderly household categories are probably worse off in terms of preparing strategies to cushion their families against adverse climatic stresses and impacts and are likely to be more vulnerable adds Opiyo et al., (2014).

From the study area, a greater percentage, 54 percent of the pastoralists were unemployed, while just 2 percent were employed. 93.8 percent of the households do not have formal education in the study area. Only 1.3 percent of the population has limited primary education and a negligible number had secondary education. The proportion with no formal education is the highest of all ranging from 85 - 90 percent notes CIDP, (2018). This scenario implies that

the target pastoralists are highly vulnerable to drought related stresses because they cannot access early warning information or read livestock extension materials to strengthen their resilience capacity. This observation is typical in ASALs of Kenya where there is usually high unemployment, low literacy level and high multi-dimensional poverty. For example, in Marsabit County, high poverty level of 83 percent was reported by GOK, (2014). This observation is consistent with finding of a similar study by Opiyo et al., (2014) in Turkana. The limited recognition of pastoralism as an important partner in economic development has led to the marginalisation of pastoral communities, thereby deepening the severity of poverty in the pastoral areas notes Nyariki et al., (2019).

The high percentage of poverty in Marsabit County is typical of ASALs of Kenya covering 80 percent of the country. The low employment percentage is due to high illiteracy and inadequate education infrastructure in the study area. There are only few primary and only two secondary schools to cater for a population of about 100,000 persons in the study area notes CIDP, (2018). There are a number of development organisations that provide employment opportunities such as working for national government, county government, civil societies and the private sector in the study area. However, the pastoral communities have limited number of diploma or university graduates to be employed.

4.3 Magnitude of vulnerabilities to drought in pastoral production systems

Many countries across the globe are adopting assessment of climate change vulnerabilities in their zones as a strategy to design strategies for interventions. This study sought to assess the magnitude of vulnerabilities to drought in the study area in order to get area specific estimate of socio-economic and ecological implications and provide detailed local information on

magnitudes of drought vulnerability, options for adaptations to drought and the impact of drought events.

4.3.1 Drought Vulnerability Index

The approach used in this study is the integrated drought vulnerability analysis, which combines socio-economic and bio-physical factors. This analysis was applied by Madu, (2012) and Desessa et al., (2008) in agro-ecological based household vulnerability analysis in Ethiopia. Vulnerability is commonly expressed as f (impact [exposure, sensitivity], adaptive capacity). These three components are used to determine the levels of drought vulnerability in rangelands explain Brown et al., (2016).

Scores of vulnerability indicator range on a scale from 0 to 1, being 0 the least vulnerable and 1 the most vulnerable has been used in Africa (Naumann et. al, 2013)

The Vulnerability Index development is based on IPCC, (2012) formula:

Vulnerability= Adaptive Capacity - (Exposure to drought + Sensitivity to drought)

The values for Adaptive Capacity, Exposure and Sensitivity is obtained from weighed values from 0 - 1.00 in the household questionnaires i.e.

$Vi = (A_1+A_2+A_3+A_4.....) - (\underline{E_1+E_2+E_3+E_4 .....+ S_1+S_2+S_3+S_4...)/Y}$

S means sensitivity while, E means exposure

Where Vi is the Vulnerability Index, while As are elements of Adaptive Capacity and Ys are elements of exposure and sensitivity. The weighed variables of adaptive capacity was summed and averaged. The sum of exposure and sensitivity was summed and averaged also. Finally the average sums of exposure and sensitivity is deducted from averaged sum of adaptive capacity to calculate the vulnerability index.

In this study, the households were classified into three categories based on the value of their vulnerability index, which puts households into highly vulnerable, moderately vulnerable and vulnerable. These intervals were used to characterise the various stages of vulnerability i.e.

1. Vulnerable if the value is 0.0 – 0.49 2. Moderately vulnerable is value is 0.5 – 0.69

3. Highly Vulnerable is value is 0.7 – 1.0.

The higher the value, the higher the vulnerability and vice versa. The values presented are not absolute but represent relative measure of household vulnerabilities. From the study findings, high proportion of the households in the study area, 65.1 percent were found to be *Vulnerable* with the Vulnerability Index being between (0.0 to 0.49). 32 .6 percent of the households were *Moderately Vulnerable* with 0.5 - 0.69 Vulnerability Index. Whereas 2.3 percent were found to be *Highly Vulnerable* with Vulnerability Index of 0.7 - 1.0 (Table 4.4).

Table 4.4 Vulnerability Index Calculations

Household NO	**ENUMERATION AREA 1=Laisamis 2=Loglogo 3=Korr 4=Ngurunit**	**Average Sensitivity Indicators**	**Average Exposure Indicators**	**Average Adaptive Capacities**	**Vulnerability index = (Exposure + Sensitivity) - Adaptive Capacities**
101	1	**0.573**	**0.475**	**0.594**	**0.42**
73	2	**0.545**	**0.340**	**0.447**	**0..54**
101	3	**0.373**	**0.343**	**0.443**	**0.45**
101	4	**0.527**	**0.400**	**0.515**	**0.42**

Figure 4.4 indicates levels of vulnerability in the entire study area including Laisamis, Korr, Ngurunet and Loglogo.

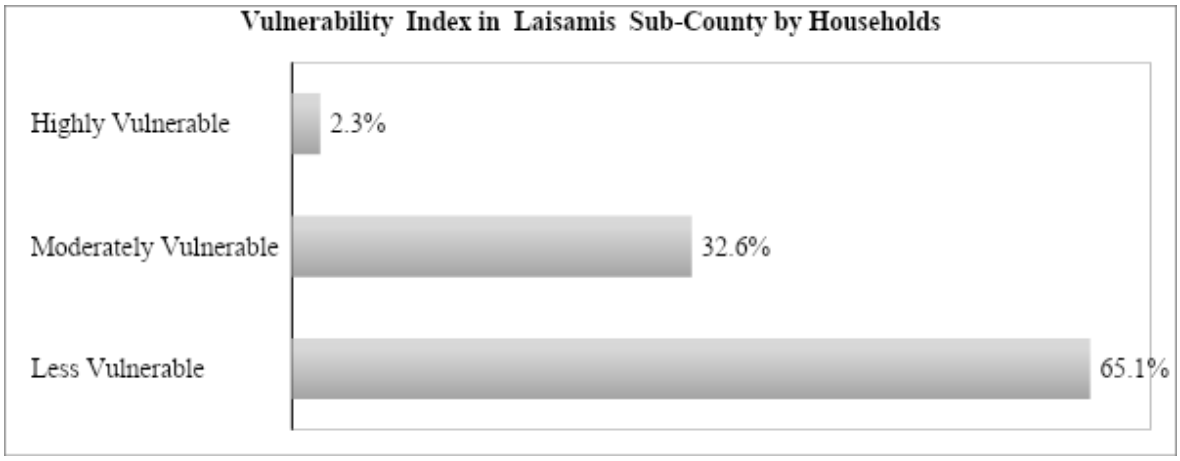

Figure 4.4: Drought Vulnerability Index for the Study Area

The results indicate that the common understanding among development organizations is that the households in the study area are highly vulnerable to drought is not consistent with the study findings. This study results show that the target community is moderately vulnerability. The results indicate low percentage of households are highly vulnerable to drought which implies that the households have adequate adaptation options to drought and have drought mitigation measures in place including complimentary sources of income to livestock, good social networks for remittances from relatives, access to technologies and other indigenous drought coping mechanisms. The average Vulnerability Index for the study area is 0.45 indicating a medium vulnerability. Accordingly the pastoral way of life, vulnerability to severe drought during 25 percent of the last 28 years while the mixed farming (livestock and maize farming combined) system was vulnerable to severe drought only during 4 percent of the years notes Biazin, et al., (2013).

In Laisamis research area, 75.9 percent of households were found to be Vulnerable with an index of between 0.0 to 0.49 and just 1.9 percent of the households are Highly Vulnerable.

While 22.2 percent of the households were Moderately Vulnerable. For Loglogo, 62.2 percent of the households were Moderately Vulnerable with an index of between 0.50 to 0.69, 4.4 percent being Highly Vulnerable. 33.3 percent of households were found to be Vulnerable in Log Logo. In Korr enumeration area, 69.8 percent of the households were Vulnerable with an index of between 0.0 to 0.49, 28.3 percent of households were Moderately Vulnerable while 1.9 percent of households were Highly Vulnerable. In Ngurnet enumeration area, 80 percent of the households were found to be Vulnerable with an index of between 0.0 to 0.49, 18.8 percent of the households were Moderately Vulnerable. While 1.3 percent of the households were found to Highly Vulnerable (figure 4.5).

Figure 4.5 shows the vulnerability index distribution per enumeration area including Laisamis, Loglogo, Korr and Ngurunet.

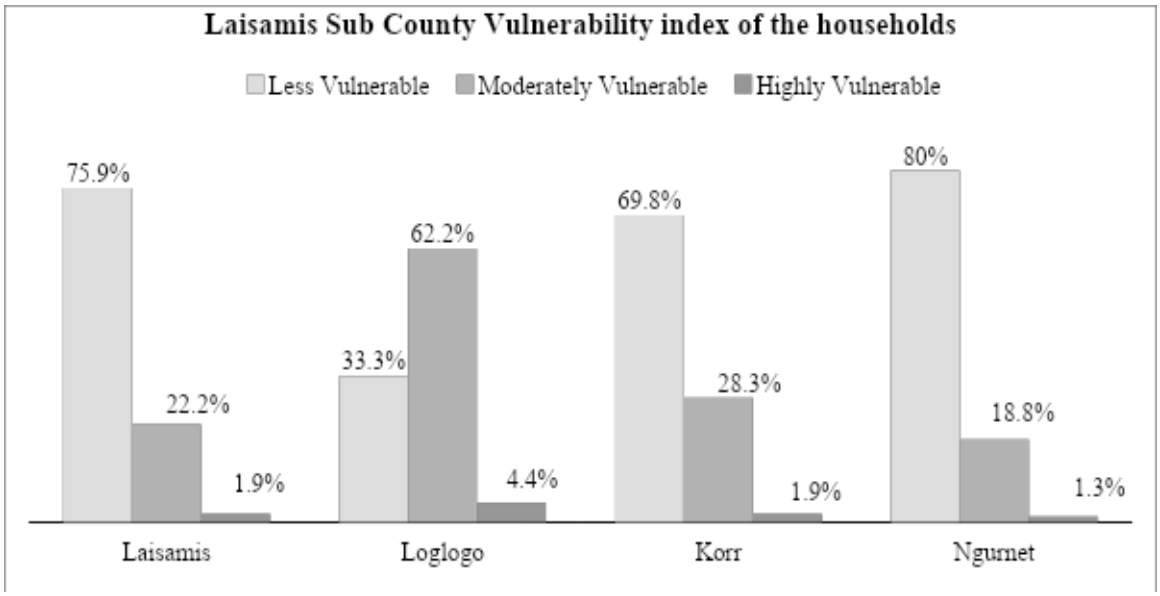

Figure 4.5: Vulnerability Index for Laisamis Sub County

The areas indicated above are locations.

Comparing the four enumeration areas, due to geographic and ecological factors, the levels of vulnerability to drought differ. Ngurunet receives more rainfall and has more livestock pasture and water sources as compared with other areas and thus 80 percent of households are vulnerable, while only 1.3 percent of households were highly vulnerable. Since Loglogo and

Laisamis are on the main international Nairobi-Addis Ababa highway, road side petty trade significantly contributes to household incomes leading to low vulnerability to drought and only 4.4 percent and 1.9 percent of households respectively being vulnerable to drought. Korr centre, though off the main international highway, has various water sources and the households have access to adequate livestock pasture leading to low vulnerability to drought of 1.9 percent of the households.

For Laisamis, Korr and Ngurunet the Vulnerability Index was 0.42, 0.45 and 0.42 respectively, which implies that households in the areas are vulnerable. Whereas for Log logo with an index is 0.54 implies moderate vulnerability. From the above findings it clearly shows that Laisamis Subcounty is vulnerable with 0.46 Vulnerability Index (Figure 4.6). This is contrary to the common belief that the pastoral communities in Laisamis are highly vulnerable to drought. This result indicates that the communities in the study are having a number of coping mechanisms to mitigate drought and have drought preparedness strategies. These include remittances from relatives, alternative livelihoods to livestock including petty trade, access to drought early warning system and livestock extension services among others.

In a similar study conducted by Fenta et al., (2018), the results revealed that 28.8 percent of the pastoral households were highly vulnerable. 53.6 percent were moderately vulnerable and only 17.6 percent of the households were capable of coping with drought. But there would be a high probability of moving from less vulnerable to a moderate or even high vulnerability level in the future if no appropriate adaptive measures are taken by decision-makers, individual households and the larger community. Furthermore, all households experienced increasing frequency of droughts, while 42 percent of the households faced flood hazards two or more times in the last 10 years making communities highly vulnerable to climate related hazard

situations explain Fenta et al., (2018). There are important geographical and thematic gaps to be filled in the assessment of drought vulnerability. Transparency in the design and validation of results should be improved, while the availability of relevant, reliable, and updated data is still a major constraint at all levels notes Tanago et al., (2016).

In a study conducted by Muricho et al., (2019), it was established that strengthening people's adaptive capacity is more cost-effective and stabilizes livelihoods more than humanitarian emergency responses. This enables them to anticipate, absorb, adapt to, and recover from the effects of shocks in a manner which protects livelihoods, accelerates and sustains recovery and supports economic and social development and transformation.

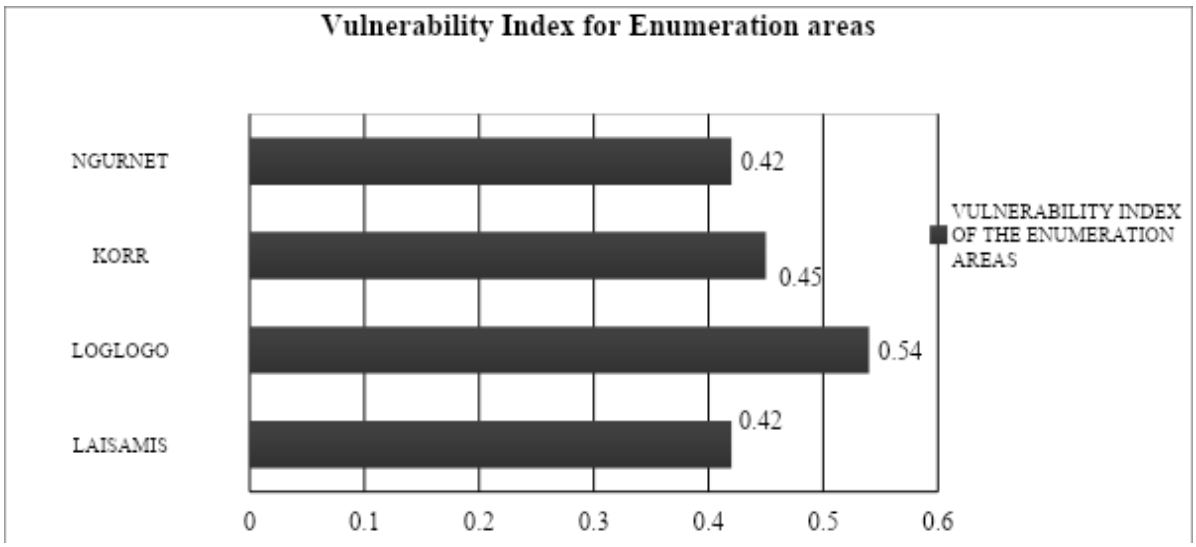

Figure 4.6: Drought Vulnerability Index in the study area

Ngurunet had Vulnerability Index of 0.42, while Korr had 0.45. Loglogo had Vulnerability Index 0f 0.54 while Laisamis had 0.42 Vulnerability Index..Loglogo had the highest vulnerability level while Laisamis and Ngurunet had lowest levels. From the above graph, the overall Vulnerability Index is about 4.6, which is moderate vulnerability.

Ngurunet was less vulnerable because the area receives more rainfall and there is income to the local community from local tourism. Laisamis also benefited from proximity to Laisamis town

were communities access local market for the livestock. Korr and Logologo had higher vulnerability due to high aridity and it had not rained for about three years.

Drought vulnerability is the exposure and sensitivity to environmental (biophysical), various social-economic, cultural, political and economic forces that determine adaptive capacity observe Yohe and Tol., (2002), Turner et al., (2003), and Skjeflo, (2013). Drought was considered by the respondents as one of the most frequent hazards in the study area. 70 percent of respondents maintained that frequent and prolonged drought events have increased in severity over the past decade. This perception corroborate Nicholson, (2014) assertion about drought events in northern Kenya, with rainfall being at least 50 percent to 75 percent below normal in almost half of the drought-stricken region and is likely to be linked to changing climatic conditions within the greater Horn of Africa. It is argued that due to the frequency of shocks in the study area, weak adaptive or coping capacity and mechanisms adopted by vulnerable households, it may result in long-term undermining of pastoralists livelihoods adds Opiyo et al., (2014).

70 percent of respondents indicated that pastoralists‘ households‘ vulnerability to drought in the study area is exacerbated by low adaptive capacity, high sensitivity of livelihoods to drought, high exposure to drought and high exposure to high aridity. Other factors that contributed to the vulnerability of the households in the study area include high level of unemployment (54%), lack of formal education among the respondents at 93.8 %, limited access to drought early warning information and livestock extension materials. Households with more members are likely to be more vulnerable than the ones with fewer members. A similar study by Opiyo et al. (2014) had the same observation in a study in Turkana, Kenya. The more dependents a household has the more likely for it to be vulnerable since a larger

proportion of household resources are directed to dependents who cannot contribute much toward household welfare. This study has shown that female-headed households, household heads with no primary level of education and households headed by divorced and widowed persons, with no access to extension services and early warning information, in particular, are disproportionately likely to be affected by drought related stresses. From the study areas including Ngurunet, Korr, Loglogo and Laisamis, the percentages of female headed households were 82.5 percent, 86.8 percent, 97.8 percent and 73.1 percent respectively.

The overall percentage from the study area of women headed households were 85 percent. In times of drought, these categories of households tend to have fewer options because livestock is the main source of livelihood.. Apart from livestock, majority of women headed households had limited access to other sources of livelihoods that may positively contribute to their resilience. Similarly, female or divorced and widowed household heads are likely not to be empowered enough in pastoral communities to make household decisions, are frequently without access to credit services and adequate capital assets or not able to own large herds of livestock to manage households‘ daily requirements adds Nabikolo et al., (2012)

Similar observations have been made by Kakota et al., (2011) in Malawi and Tesso et al., (2012) in Ethiopia that widowed or divorced household heads are more vulnerable because they rely on income earned by either the father or mother as the bread winners. However, a study by Deborah et el., (2019) contradicts these findings and showed that male-headed households were less resilient compared to female-headed households. Studies by Opiyo et al., (2014) and Tesso et al., (2012) found that female-headed households were less resilient largely due to bias in resource allocation and decision making that leans towards males in most pastoral communities. The results and contradictions can be explained by the observation of IIRR and

CTA, (2012) which noted that there are emerging trends in pastoralists communities where women are increasingly taking charge of managing livestock enterprises such as poultry, thereby putting them in a position to build their resilience sometimes even better than men. This could also be explained by the fact that this study, Opiyo et al., (2014) and Deborah et al., (2019) studies were conducted among different ethnic groups including Rendile, Turkana and Pokot in different geographical location and socio-economic divergence.

The findings of this study suggest the households in the study area, Laisamis Sub-County, had vulnerability index 0.46.. Other studies have indicated that in Turkana region, with a similar livelihood pastoral system, has a number of households with high dependents on famine relief, low engagement in off-farm activities and low levels of education notes Blench, (2000), McPeak and Barrett, (2001), Watson and van Binsbergen, (2008). However, for the study area, there is low dependence on external support, while levels of formal education and other non-livestock related income sources are limited.

The determinants of households‘ vulnerability were found to be significantly influenced by the gender of the household head i.e in the study area 85% of households were headed by women while only 15% was headed by males , age of the household head (35 – 60), size of the household (2 – 16), number of dependents (2 – 16) , marital status (married, widowed, or single by choice) , social linkages (membership to different social groups (80 % of respondents were members of social groups and 20 % did not belong to any group), access to extension services (63 % had access to extension services while 37 had no access), 49 % of respondents had no access to early warning information and 51 % had access to moderate extension services. Most, 61 percent of respondents had no access to appropriate technologies including mobile

telephones while only 39 percent had access. Most 82 percent of respondents had no access to productive assets, while only 18 percent had access.

Table 4.5: Key determinants of drought vulnerability results

Key component	Contribution to vulnerability
Age of households	35-60; 2-16;
Number of dependents	2 - 16
Size of households	2 - 16
Marital status	Married or single
Membership to social groups	80 % membership; 20 % non member
Access to extension services	63 % had access; 37 % had no access
Access to Early Warning System	51 % had access; 49 had no access
Access to appropriate technology	61 % had no access; 39 had access
Access to productive assets	82 % had no access; 18 % had access
Employment	54 % unemployed; 42 % self-employed; 4 % engaged in unspecified income sources
Remittances	55.7 received remittances; 44.4 did not receive
Access to credit	52.8 % had no access to credit; 47.2 % had access to credit
Level of education	93.8 % had no formal education; 0.2 had primary education, 6 % had secondary of higher education.

Membership in social groups was 80%, while 20% did not join any group. 63% of households had access to extension services while 37% did not have. 51% had access to early warning systems while49 % had no access. 61% had access to appropriate technology while 39 % had none. 82% had access to productive assets, while 18% had no access.Unemployment was at 54 percent while 42 percent were self-employed and 4 percent were engaged in unspecified income sources. 55.7 percent of respondents received remittances from relatives working outside the study area while 44.3 percent did not. The study found that 52 .8 percent had no

access to credit facilities while 47.2 percent of the respondents had moderate access. Level of education also played a critical role in contributing towards drought resilience. Most, 93.8 percent of respondents had no formal education while only 0.2 percent had primary education. In addition, non-farm income, herd size and diversity, herd structure and herd mobility, access to markets, households' employment status, coping strategies and access to credit were also observed to be the determinants of the households' vulnerability to drought. This concurs with studies by Eriksen et al., (2005) and Notenbaert et al., (2013) which similarly observed some of these

factors to be the key determinant of households' vulnerability to drought. These results are consistent with previous findings by Kakota et al., (2011) and Gebrehiwot and van der Veen., (2013). From these findings, it seems there is still more to be done to understand vulnerability and its underlying processes.

4.3.2 Relationship between Vulnerability Index and number of livestock owned

Number of livestock owned has significant influence on vulnerability to drought on pastoralists. This is because livestock is the main livelihood source for the pastoralists. Due to climatic conditions in the study area, livestock is the major livelihood source for the survival of the target community in the fragile ASAL environment. Therefore, it is important to consider livestock number when assessing drought vulnerability index. The correlation of Vulnerability Index and number of livestock owned is illustrated in Table 4.6.

Table 4.6: Correlation between Vulnerability Index and number of livestock owned

		Vulnerability Index
Livestock Unit	Pearson Correlation	-.010
	Sig. (2-tailed)	.851
	N	373

The study assessed the vulnerability by examining the cattle production as indicated by livestock numbers, as exposed to stressors related to change in weather within the time of the study. There is a weak negative (r=-0.010, p= 0.02) linear relationship between Vulnerability Index and number of livestock owned (table 4.6). The weak relationship is due to various other factors contributing to drought vulnerability. This means that for every increase in the number of livestock owned, there is a decrease in vulnerability index since livestock is a major livelihood source for pastoralists in the study area.

These findings concur with recent literature by Füssel and Klein, (2014) who argued that the vulnerability of a system can be seen as the combination of exposure, sensitivity and adaptive capacity factors which affect the supposedly inverse linear relationship between the two variables. This finding resonates with arguments by Bett, (2017) that vulnerability brought about by climate variations leads to reductions in livestock productivity by directly depressing animals‘ adaptive response mechanisms, altering the spread and prevalence of diseases. Similarly, Morignat, (2014) adds that increased vulnerability causes social stress and related welfare issues pushing pastoralists to sell off their herds even at prices less than real value. Increased vulnerability that indirectly compromises the availability of feed crops and quality of forages thus decreasing livestock numbers explains Giridhar, (2015.

4.3.3 Relationship between Vulnerability Index and livestock prices

Livestock prices play significant role in determining Vulnerability Index as illustrated in table 4.7.

Table 4.7: Correlation between Vulnerability Index and Livestock prices

		Average Livestock Prices
Vulnerability Index	Pearson Correlation	-.006
	Sig. (2-tailed)	.01
	N	373

There is a weak negative (r=-0.006, p= 0.01) linear relationship between Vulnerability index and prices of the livestock (Table 4.7). This means that for every increase in the prices of the livestock, there is a decrease in vulnerability index. Livestock prices contributed minimal to vulnerability because there were various other determinants and factors contributing to the same.

Table 4.8 Livestock prices in the study area

	Sheep/goats (ksh)	Cattle (ksh)	Camels (ksh)
Loglogo	4,000	30,000	40,000
Laisamis	4,000	30,000	40,000
Korr	3,000	25,000	25,000
Ngurunet	3,000	40,000	30,000

Sheep and goat prices in Loglogo and Laisamis was Ksh. 4,000 per animal, while in Korr and Ngurunet sold for ksh. 3000. Cattle were sold for ksh. 30,000 in Loglogo and Laisamis, while

Korr it fetched Ksh. 25,000 in Korr, while the price per cattle was ksh. 40,000 due to better body condition. Camels were sold for ksh. 40,000 in Loglogo and Laisamis, while Korr prices for a camel was ksh. 25,000. In Ngurunet camels were sold for ksh. 30,000.

These results conform to the Rosen‘s hedonic pricing model which is based on the hypothesis that goods are valued based on their attributes as developed by Rosen, (1974). The findings are consistent with findings elsewhere by Andargachew and Brokken, (1993) on sheep pricing in highland of Ethiopia. Jabbar, (1998) on small ruminants in southern Nigeria showed vulnerability caused by climatic changes affect livestock attributes such as condition and size that affect the prices livestock fetch at market. These findings are consistent with that from elsewhere in the East African ASAL that livestock prices and mortality rates are negatively correlated, implying that prices do not move to stabilize pastoralist incomes in the face of yield shocks. Coppock, (2014) explains the reason for such trends in which good rainfall years raise and stabilize livestock prices while drought years lead to low and unstable prices. This later creates disincentives and reduces herd sizes through sales in times of stress. This helps to explain the puzzle of low marketed off-take rates that contribute to pronounced livestock cycles observed in the study.

The consequent result of high vulnerability index as in case with communities in northern Kenya, was observed by Dawe, (2012) to cause imperfect competition depicted by high price elasticity, low expansion of market niches as well as restricted gain between the market players, which eventually results into slow growth of the overall industry. This slow growth due to prolonged vulnerability explains the negative weak relationship between vulnerability and livestock prices. Semenza and Menne, (2009) argued that when prices diminish then the communities‘ vulnerability index increases as found out in this study.

4.3.4 Relationship between Vulnerability Index and availability of pasture (Chi test)

Natural pasture provides the primary source of feed for livestock to the pastoralists in the study area. Without pasture there would be no livestock and no humans living in the study area. Pasture cultivation is not possible without adequate rainfall. Pasture availability significantly contributes towards drought vulnerability. Hence the need to consider the relationship between vulnerability index and pasture availability. Table 4.9 shows the relationship between vulnerability indices and pasture availability.

Pasture availability plays significant role in determination of vulnerability index as shown in table 4.10.

Table 4.10: Relationship between Vulnerability Index and availability of pasture (Chi square test)

		Vulnerability
Pasture Cover	Pearson Chi-square	24.860
	Asymp. Sig. (2-sided)	0.000
	Cramer's V	0.455
	Df	1
	Cohen‘s Index(w)	0.455

The Chi square results indicated that there is a significant relationship between Vulnerability Index and availability of pasture. X^2 (1) =24.860, p=0.000 (table 4.5).

Relationship between pasture availability and vulnerability is illustrated through Cohen‘s Index shown in table 4.11.

This finding resonates with a study by Kosonei et al., (2017) that vegetation cover was severely affected when drought periods were long and intense. Bare grounds devoid of vegetation cover

were common during prolonged and intense droughts as it was experienced during the year 2000 La Nina drought. As the inhabitants strived to cope with the effects of droughts, they turned into their immediate environment exploiting the available vegetation resources. This led to destruction of vegetation cover through activities such as overgrazing on wetlands and forested areas, charcoal burning and clearing of vegetation for crop farming. Thus, if environmental degradation remains unchecked, the study area will gradually become a desert.

Muricho et al., (2019) also agree that Pastoralists are affected the most when shocks such as droughts strikes since water and pasture become scarce. This results in low milk and meat productivity, which are the main components of pastoralists‘ diet, leading to food insecurity and high vulnerability to drought. Similarly, Kachergis et al., (2014), observed that, livestock ranching operations are vulnerable to production risk because forage production in rangeland ecosystems is linked to growing season precipitation which is highly variable within and between years. Drought reduces the number of livestock rangelands can support, individual animal productivity and supply of essential commodities like irrigation water for hay production leading to high drought vulnerability.

Table 4.11: Relationship between vulnerability index and availability of pasture

w (Cohen'sIndex)	
0.00 to 0.30	Small
0.30 to 0.50	Middle level
0.5 and above	Large

Reference values for interpreting Cohen's Index (Adapted from Cohen, (1988)

With reference to Table 4.6, adopted from Cohen, (2013) and as discussed by Gray and Kinnear, (2012), it is concluded that the relationship between vulnerability index and availability of pasture in the study area is medium, w=0.455. This from the graph prepared for the whole study area.

The assessment of drought vulnerability applied in this study, has largely reinforced the concept of Wilhite, (2014) and Wilhelmi et al., (2012) that drought can be viewed as a product of both the exposure to the climatic hazard (e.g. low rainfall) and the underlying vulnerability of livestock rearing practices, primarily due to low pasture availability. The significant relationship between vulnerability index and availability of pasture reinforces findings by Smith, (2016) in which he established that lack of pasture will increase vulnerability in four ways: the impact of changes on livestock feed-grain availability and price; the impact on livestock pastures and forage crop production and quality; changes in livestock diseases and pests; and the direct effects of weather and extreme events on animal health, growth and reproduction. All these events are linked to increased community vulnerability especially during drought explains Smith (2016).

However, Semenza and Menne, (2009) established a different reason explaining the relationship between vulnerability index and availability of pasture. The authors indicated that alterations in pasture availability may result in the spread of disease and parasites or produce an increase in the incidence to which a particular disease is already prevalent, which will lead to a decrease in animal productivity and increase in animal mortality thus affecting greatly returns from livestock production. It was found that investing in enclosures increased the probability of a household having less drought vulnerability explain Deborah et al., (2019). Those households least affected by the drought, in terms of cattle lost, were those with large herds who were able to sell some of their cattle and to pay for private access to pastures outside of Maasai areas adds Mara et al., (2013). The pastoralist livestock systems common in these

areas are highly dependent on natural resources such as pasture, fodder, forest products and water, all of which are directly affected by climate variability notes Houri et al., (2013). People in such areas have developed complex strategies such as mobile pastoral systems to access pasture to deal with climate variability and change notes Brooks et al., (2009). With poor access to pasture, livestock and the communities become highly vulnerable to drought.

The results are consistent with previous findings by Deressa et al. (2008) in a similar ecosystem. However, for the biophysical variables, the greater the level of household reliance on natural resources, such as pastoralism or dry land crop farming, the greater will be their vulnerability to climate variability and change. This is partly because the use of such natural resources is dependent on rainfall, which is projected to change. This study observed that almost all the biophysical and environmental variables contribute positively to household vulnerability. It is likely that the level of dependence on natural resources especially pastures and water will vary from household to household. For example, while the majority of households depend on livestock herding as their main source of livelihood, for others, livestock is just an equal or lesser contributor besides other economic activities. Therefore, there is a trend towards seeking alternative livelihood sources such as employment, small scale irrigation and trading in food items.

4.3.5 Relationship between Vulnerability Index and number of water bodies (sources)

Water is a critical resource that enables livestock and humans to live in the ASALs and forms the basis for livelihoods. Therefore, the number of water bodies is key element when discussing vulnerability index. The relationship between water source numbers and vulnerability index is illustrated in table 4.12. \

Table 4.12: Correlation between Vulnerability Index and water bodies

		Sources of Water
Vulnerability Index	Pearson Correlation	-.256
	Sig. (2-tailed)	.000
	N	362

There is a weak negative (r=-0.256, p= 0.00) linear relationship between Vulnerability index and number of water sources. This means that for every increase in the number of water source, there is a decrease in vulnerability index. The weak relationships may be due to various other factors having significant contribution towards vulnerability including access to technologies, credit facilities, membership of social-economic groups, access to education and medical facilities. A strong conclusion may not be attainable because numbers of water bodies are only one of the various contributors to vulnerability. Other bio-physical and socio-economic factors need to be considered in making conclusions on vulnerability levels.

The finding conforms to Zeigler et al, (2014) that number of water bodies does not play a significant role towards vulnerability; however it is the water volumes and number of humans and livestock who are supported by each water body that matter most. Veena et al., (2013) agrees that vulnerability to water shortages depends on a combination of several factors: the formal water infrastructure, the rate and spatial pattern of land use change, adaptation by households and the characteristics of the ground and surface water system. Sharma, (2010) contradicts this finding that local rich people took illegal lease of all the water bodies from Government to form a so called fishermen group due to lack of distribution law but in reality

the poor fishermen have no access to these water bodies. If the poor people could get the opportunity to catch fish in these water bodies, they could easily earn a good amount of money by selling it. This scenario largely contributed to fisher folks‘ vulnerability to drought. Hummell et al., (2016) agrees that in a study in Brazil, households that have water provided by water trucks, rivers and other water bodies such as rainwater as having no water infrastructure, and thus are highly vulnerable.

4.3.6 Relationship between Vulnerability Index and Livestock species diversification (No. of livestock species)

Livestock species diversification is one of the key traditional adaptation strategies that have enabled pastoralist communities to survive harsh environmental conditions for centuries explain Sperenza, (2010). Diversification of livestock herds has both ecological and economic implications as different livestock species have different water and pasture requirements and react differently to droughts and diseases. Different livestock species have varied adaptation to drought conditions and therefore significantly contribute towards drought vulnerability of pastoralists. The relationship between vulnerability index and livestock species diversification is illustrated in table 4.13.

Table 4.13: Relationship between Vulnerability Index and number of livestock species

		Cattle	Camels	Goats	Sheep	Donkeys
Vulnerability Index	Pearson Correlation	.017	-.039	-.025	.011	.100
	Sig. (2-tailed)	.747	.459	.632	.840	.059
	N	364	364	364	364	361

There is a weak positive (r=0.017, p= 0.747) linear relationship between Vulnerability index and the number of cattle owned. This means that for every increase in the number of cattle, there is an increase in vulnerability index. Similarly, there is a weak positive (r=0.100, p=

0.059) linear relationship between Vulnerability index and the number of donkeys owned. There is a weak positive (r=0.011, p= 0.840) linear relationship between Vulnerability index and the number of sheep owned. The reason for weak relationship is because of other various factors contributing to drought vulnerability . This means that for every increase in the number of sheep, there is an increase in i access to education vulnerability index. There is weak negative (r=-0.039, p= 0.459) linear relationship between Vulnerability index and the number of camels owned. This means that for every increase in the number of camels, there is a decrease in vulnerability index. In addition, there is a weak negative (r=-0.025, p= 0.632) linear relationship between Vulnerability index and the number of goats owned. This means that for every increase in the number of goats, there is a decrease in vulnerability index.

Respondents reported that new breeds that are drought tolerant and consume less pasture including Turkana camels and Galla goats are now reared by pastoralists in Marsabit County. They reported that new breeds of goats and sheep consume less forage when compared to cattle and they also produce nutritious milk. This is likely to reduce vulnerability among communities with rapid population growth rate as observed by Sperenza, (2010). Diversification in livestock species including cattle, camels, goats, sheep and donkeys, will significantly contribute towards reducing vulnerability to drought.

Hoffmann, (2009) suggested that the use of multi-species and multi-breed herds is one strategy that many traditional livestock farmers use to maintain high diversity in on-farm niches and to buffer against climatic and economic adversities which leads to decreased vulnerabilities. The study established that communities in Marsabit County use traditional diversification practices for adaptation to adverse weather conditions and to reduce vulnerability during times of distress. These findings are in line with Seo and Mendelsohn, (2008) who modeled that small

livestock farms in developing countries were found to be more climate change resilient due to their diverse species portfolios and the ease with which they can shift between species. Commercial dairy and beef livestock were more vulnerable than smaller species like sheep and goats, because of low feed and water requirements. The study went further to determine whether there is a relationship between vulnerability index and livestock species diversification and to determine the strength there of for the relationship.

The outcomes of these correlations imply that local breeds are more adapted to pastoral systems than others. Selection within the same breed and introducing drought tolerant breeds will significantly reduce drought vulnerability. These findings augment studies by Gouro, (2014) and Seo and Mendelsohn, (2013) in the Sahel who established that species substitution due to climate and vegetation changes occurs during extreme conditions where dromedaries replaced cattle and goats replaced sheep, following the droughts of the 1980s. Gouro, (2014) adds that, reinforces the current findings in that it established countries such as Niger and Mauritania, and in northern Nigeria where camel rearing is now a common activity as pastoralists sought to lower recurring vulnerabilities during dry seasons which have become more frequent. Unlike cattle and sheep, which largely feed on herbaceous vegetation, camels browse on shrubs and trees, while goats use both strata. Mendelsohn, (2013) found the positive relationship between camel and other browsing species has several advantages in that: the higher browse strata cannot easily be used by other species and tends to offer green forage also during the dry season to camels while medium and herbaceous layers are used by other livestock species. For efficient use of resources at every stratum, different livestock species need to be kept by pastoralists as a means of reducing vulnerability and enhance resilience on long-term sustainable basis.

4.4 Adaptation options to drought in pastoral production system in Laisamis

Livestock species and the number owned determine the levels of adaptation to drought among pastoralists. As presented for cattle, goats, sheep, camels and donkeys, the findings in the table 4.9 (page 66) indicates low ownership of livestock units of less than 20 by 52 per cent of respondents, ownership of 21 – 40 units by 24 percent, ownership of 41 – 60 units by 9.4 percent and ownership of more than 61 livestock units by 14.3 percent. Livestock unit in cattle is cow and calf, while in other species is the individual animal. The findings indicate that, though livestock is the main livelihood among the respondents, there may be falling out of reliance on livestock and diversifying into other livelihoods. Some respondents may have lost livestock to cattle rustling or drought. This implies that there is need to invest in other complimentary livelihoods by pastoral communities. Recent discourse on pastoralism and ecology has focused on increased stocking densities and subsequent consequences on grasslands and productivity. It has been shown that increase in livestock numbers may adversely affect pasture availability. Trend in livestock numbers and composition determine social-ecological linkages in this pastoral community.

As opposed to previously reported trends, we find that livestock numbers have essentially halved in the last decade and the reduced holdings also are compositionally different from the original stock. Pastoralists have an intimate relationship with their environment and a rich knowledge that enables them to both protect and exploit the changing rangeland conditions on which they depend upon notes Notenbaert, (2012). Understanding how pastoral communities adapt to and cope with extreme climatic conditions, particularly drought, becomes even more important as pastoralism already faces environmental, political, and socioeconomic marginalization. Livestock ownership distribution is shown in table 4.14.

Table 4.14: Livestock Ownership distribution

		Livestock Unit				
		Below 20	**21 to 40**	**41 to 60**	**61 and above**	
Livestock Species	1 Livestock Species	48.0%	32.0%	12.0%	8.0%	100%
	2 Livestock Species	58.6%	19.0%	12.1%	10.3%	100%
	3 Livestock Species	58.1%	18.6%	12.8%	10.5%	100%
	4 Livestock Species	50.0%	29.6%	5.1%	15.3%	100%
	5 Livestock Species	47.3%	23.2%	8.9%	20.5%	100%
Total	means	52.3%	24.0%	9.4%	14.3%	100%

The means of livestock species and number of livestock units owned determines the levels of adaptation to drought among pastoralists. Livestock species 1, 2, 3, 4 and 5 represent cattle, goats, sheep, camels and donkeys respectively. 52.3 percent of respondents owned less than 20 livestock, 21 - 40 livestock units were owned by 24 percent , 41 - 60 units were owned by 9.4 percent and 14.3 percent owned 60 livestock units or more.

These findings indicates that majority of respondents, 52.3 percent, owned 20 livestock units, while few respondents, that is 9.4 owned more than 60 livestock units or more. This result indicates that drought vulnerability is high among the respondents unless reliance on livestock livelihood is complimented by other means, for example petty trade. Dependence on small business (petty trade and shops) as the main economic activity, ownership of various assets, such as forage and participation in village-level saving schemes were all significantly associated with reduced household vulnerability explains Birhanu et al., (2021).

4.4.1 Relationship between livestock, diversity and livestock body condition

Livestock ownership, diversity and quality of livestock determine the adaptation capacity to drought among pastoral communities. Table 4.15 illustrates the relationships between livestock ownership and diversity.

Table 4.15: Relationship between livestock ownership and diversity (Chi-Square Tests)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.327[a]	18	.032
Likelihood Ratio	20.202	18	.022
Linear-by-Linear Association	2.634	1	.005
N of Valid Cases	376		

The chi-square result indicates weak relationship between livestock ownership and diversity. The community own large, medium and few animals but there is low indication of livestock species diversity that includes cattle, camels, sheep, goats and donkeys.

Table 4.16 shows species distribution among the respondents of cattle and camels, table 4.17 shows species distribution for goats and sheep while table 4.18 shows donkey ownership distribution among the respondents.

Table 4.16: Species distribution for cattle and camels

Cattle				Camels		
Valid	**Number of cattle owned**	Frequency	Percent	**Number f camels owned**	Frequency	Percent
	None	75	19.8	**None**	100	26.3
	1-20	243	63.8	**1-20**	247	65.1
	21-40	33	8.9	**21-40**	24	6.5
	41-60	15	4.2	**41-60**	2	0.8
	61-80	3	1	**61-80**	1	0.5
	81-100	4	1.3	**81-100**	1	0.3
	Above 101	3	1	**Above 101**	1	0.5
	Total	376	100	**Total**	376	100

Table 4.16 indicates low ownership of large cattle and camel numbers. Camel numbers are quite low. Majority of community members own 1-20 cattle at 63.8 percent, while 65.1 percent of the community own the same numbers of camels. Very few community members own 40 - 100 cattle or camels. This is an indication of generally low livestock ownership in the study area. The livestock may have been lost to droughts, floods or livestock rustling which is common in the study area.

Table 4.17: Goats and sheep distribution

Goats			**Sheep**		
Number of sheep and goats owned	Frequency	Percent		Frequency	Percent
None	13	3.4	**None**	21	5.5
1-40	281	74.7	**1-40**	307	81.5
41-80	54	14.3	**41-80**	35	9.6
81-120	17	4.7	**81-120**	11	2.9
121-160	2	0.5	**121-160**	1	0.3
161-200	6	1.6	**161-200**	1	0.3
Above 201	3	0.8	**Total**	376	100
Total	376	100			

74.7 percent of respondents owned 1-40 goats, while 81.5 percent owned 1-40 sheep. 14.3 percent owned 41- 80 goats, while 9.6 percent owned sheep. The rest of the community owned very few goats and sheep in the category of 80 - 200 per household. This community, according to the pastoral small stock ownership can be classified as poor.

Table 4.18: Donkeys distribution

Donkeys		
ıber of donkeys owned	Frequency	Percent
None	160	42.7
1-3	196	52.1
4-6	12	3.1
7-9	5	1.3
Above 10	3	0.8
Total	376	100

Donkeys are not usually kept in large numbers in the study area. A household may own one donkey or none at all. 52.1 percent of the respondents owned 1 - 3 donkeys while 3.1 percent owned 4 -6 donkeys. The rest of the households with 7 - 10 donkeys were insignificant.

The study found that considerable changes are taking place in livestock population, herd composition and management systems based on predominance of livestock species. Changes in livestock population are closely associated with forage and pasture availability. The households‘ perceptions about the changes in their herd sizes show that the total livestock population is increasing (tables 4.16. 4.17, 4.18). Herd accumulation has been argued as well as to some extent demonstrated empirically, to be an effective strategy for buffering environmental hazards for short periods of time because it seems that wealthier pastoral households cope with weather calamities better than poorer ones observed Naess et al., (2013). The positive relationship indicates that as herd size increases, losses also increase: increasing

herd size by one animal in 1998 increases the expected losses by 0.44 notes Naess et al., (2013). Herd accumulation is therefore not an effective strategy for countering the negative impacts of environmental hazards observes Naess, (2013).While herd accumulation seems to be an efficient strategy it is determined by periods of recuperation when herd growth is possible. In fact, a delay in restocking after environment-induced losses is one of the main problems of pastoral production system. Herd accumulation can thus be expected to work less efficiently, if at all, when the frequency of extreme events increases explains Naess et al., (2013).

The main reason for the changes in herd composition are income level based on livestock and market demand for livestock and its products in general. The most noticeable change is the considerable decline in cattle, goat and sheep numbers among pastoral households. The higher number of cows correlates with the major reason of keeping dairy cattle, mainly for selfconsumption and selling extra products in the market, and using dung as fuel.

Donkey numbers increased due to the necessity of transport for the household and this is an indication of advanced rural poverty. The poor prefer to use livestock in order to avoid extra expenditure for tractor services, such as fuel and rent payments to tractor owners for transportation. Environment-induced losses are one of the main problems of pastoral production. Herd accumulation can thus be expected to work less efficiently with increase of frequency of extreme weather events such as droughts observe Naess et al., (2013).

Pastoralists balance herd size, species and breed composition, grazing pattern as well as other livelihood options, with an eye to managing climate risk, even if other risks such as social, economic or conflict are more immediate observe coppolilo, (2000), Ketter, (2005), Homewood, (2008) in Eriksen et al., (2013). Climate risk is a core driver of livestock population dynamics due to inter annual and inter seasonal variability and rainfall influences

fodder availability and depending on the context, patterns of herd growth and mortality describes Ericksen et al., (2013).

4.4.2 Relationship between access to drought early warning systems and water availability

Access to drought early warning systems and availability of water sources play significant role in determining the f adaptation capacity to drought by pastoralists. This study finds that the main sources of water during droughts in Marsabit County were water pans and dams as reported by 87 percent of the respondents followed by shallow wells reported by 84.1 percent of the respondents. Boreholes accounted for 30.4 percent of the community which relied on boreholes as sources of water. Other sources of water were reported by 15 percent of the respondents. It should be noted that the level of access to these water sources are not reliable to community in case of extreme drought conditions. To determine the of the relationship, Chi-Square test was computed in order to determine the level of effectiveness of the EWS in resulting to execution of actions leading to reliable access to water. The results are as presented in the table below 4.19.

Table 4.19: Main Source of Water and access to climate related disaster early warning systems Cross-tabulation

		Access to climate related disaster early warning systems 1=No access 2=Moderate access 3=Adequate access		
		No access. (1)	Moderate access (2)	Adequate Access (3)
Main Source of Water	Surface rain water	62.1%	37.9%	Non
	Water pan/Dam	13.0%	87.0%	"
	Borehole	69.6%	30.4%	"
	Shallow well	15.9%	84.1%	"
	Others	5.0%	15.0%	"
Total		50.9%	49.1%	"

A drought EWS is designed to deter the emergence of probability of occurrence and the likely severity of drought and provide warning on potential threats notes WMO, (2016). EWS is designed to alert pastoral communities on climate. related water availability linked to shorter or longer periods specifically for non-irrigated natural pasture observes Jageskog et al., (2012).

Table 4.9: Relationship between Vulnerability Index and availability of pasture

Do you haveAccess pasture? **1=No access** **2=Moderate access** **3=Adequate access**	Vulnerability Index	Frequencies
2	0.5	379
3	0.3	1
1	0.8	4
Average	**0.48**	

The findings from Chi-Square analysis indicate that all the results are significant at 95 percent confidence level (a=0.05). This meant that the Early Warning Systems have led to increased access to water for communities through community drought preparedness to ensure that there are adequate water sources.

These findings concur with findings by Wilhite, (2014) who argued that drought preparedness is often related to developing planning strategies. This leads to execution of relevant actions to alleviate impact at extreme conditions. The study established that there was increased access to water from manmade sources as a result of recommendations from the EWS data. The survey results indicated that triggers and thresholds were very important in getting execution actions. At the same time drought management options are highly valued. The results showed that the majority of the community (87 percent) access water from water pans and dams giving credence to recommendation by Andreu, (2013) who posed that one of the best strategies to respond to drought is to repair damage caused by drought (post-disaster) and to act pro-actively towards a drought by adequately preparing the society. This aims to limit the impact beforehand by reducing the exposure to the drought threat. The majority of the survey respondents (87%) agreed with this approach. Wolters, (2015) also quoting Andreu, (2015) emphasized that this approach was an important option to lower drought impacts. The results showed that drought resilience can lower the exposure to the hazard by improving the coping capacities through preparation and mitigation strategies especially by diversifying water sources.

The rationale of early warning is majorly to invent in premeditated interventions so as to avert further advancement of early-stage disasters. As Oshita, (2010) stated, preventive actions are required to ensure protection of productive assets. In this study, early warning systems were assessed based on their impact in gathering and substantiating information, and in addition

whether the data helped in taking up measures to conserve and make water available during drought. This, as observed by Karin, (2013) is the functionality of a working EWS which calls for the analysis of EWS data, the dissemination of the findings to all significant stakeholders, and the conception and execution of actions. In the current study, the functionality of EWS was measured by the presence or lack thereof of alternative sources of water during drought through the presence of water pans, boreholes and springs.

Experience from Malawi in 1991–1992 indicated that in areas such as the southern escarpment, prolonged drought resulted in the drying up of shallow wells resulting from the absolute scarcity of water. In other areas, however, ground water was available within aquifers, but could not be accessed because of individual ownership observes Calow et al., (1997). A key conclusion, supported by later work in Ethiopia, was that both availability and access to water were important, and that although there was generally an increase in the failure of wells, springs and boreholes during drought (and often beyond), the link between drought and source failure was not clear-cut observes Roger et al., (2010). Linkages with drought early warning system may result in effective preparedness to address water deficits during drought periods.

Access to water was critical, particularly for poorer households, with access determined by the coverage and functionality of water infrastructure and by the ability of a household to draw on labour and other assets to secure supply during drought periods explains Roger et al., (2010). A drought early warning is essential for the low income groups because storage infrastructure is not adequate.

4.4.3 Relationship between access to Drought Early Warning Systems and availability pasture

Access to drought early warning systems and pasture availability have significant relationships that contribute towards drought adaptation by pastoralist communities. Access to early warning information and access to private ranch grazing by household are the key determinants of the choices of adaptation strategies to cope with drought and climate change observes Nderitu, (2021). There is need for early warning institutions to increase their visibility in the semi-arid pastoral areas by exploring effective methods of delivering climate risk information in good time. Tonya et al., (2021), observe that the influence of drought early warning information was very influential in managing pasture. Table 4.20 shows access to early warning systems, while Table 4.21 indicates the relationship between earning warning systems and pasture availability.

Table 4.20: Early Warning Systems Access

		Frequency	**Percent**
Valid	No access	200	60.1
	Moderate access	184	39.9
	Total	**376**	**100.0**

The community access to early warning system is through monthly drought data collection by NDMA. The level of access is determined by the coverage of NDMA of various villages Within the study area.

The results indicate that 60.1 percent of households do not have access to climate related disaster early warning systems and just 39.9 percent had moderate access (table 4.15). Access to disaster early warning systems according to the four enumeration areas is described in figure 10. For Laisamis and Ngurnet, there is a wide difference with a high fraction for those who have No access (88.9%) and (16.3%) respectively to climate related disaster early warning

systems. Log logo had 43.3 percent No Access while Korr had 49.1 percent No Access to disaster early warning systems. 11.1 percent, 56.7 percent, 50.9 percent and 83.7 percent have Moderate Access in Laisamis, Loglogo, Korr and Ngurunet respectively (figure 4.7).

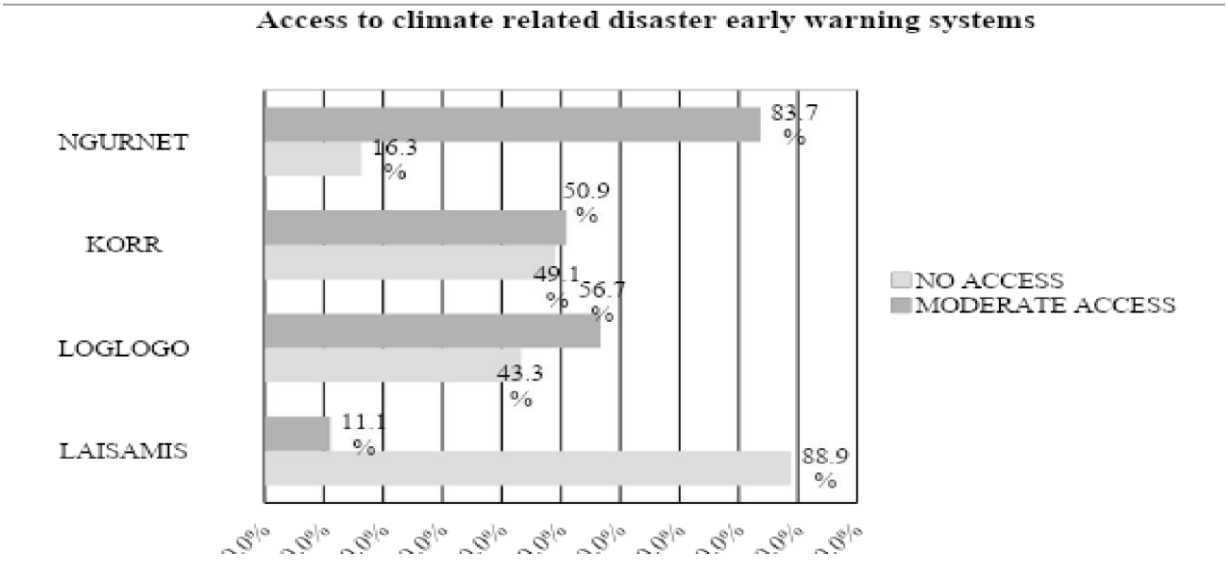

Figure 4.7: Disaster Early Warning systems access

The results indicate that 60.1 percent of households do not have access to climate related disaster early warning systems and just a 39.9 percent had moderate access (table 6). Access to disaster early warning systems according to the four enumeration areas is described in figure 4.7. Ngurunet had 83.7 % access to early warning system while 16.3 % had no access. In Korr 50.9 % had access while 49.1% had no access. Logologo had 56.7% accesss while 43.3% had no access. In Laisamis, only 11,1 % had access to early warning system, while 88.9% had no access,

The Chi-Square Results show that there is a significant positive relationship between access to EWS information and access to pasture. These results pay credence to earlier findings by Toulmin, (2010) in which he modeled that there is a general trend in a pastoralists' economy which are likely to occur during a drought period and are positively impacted by preparedness

from early warning systems. However, the study findings were at variance with Scoones, (2012) who pointed out that pastoralists respond to declining forage availability with the adjustment or, if possible, movement of their herds as the access to pasture was related to reduction of stocks and storage. The study findings also support literature by Davies, (2014) that EWS improve pastoralists coping activities during a drought by changing their livelihoods to cope with declining resources (e.g. water, forage). Davies, (2014) argues that coping activities evolved from opportunities to change livelihood strategies in order to improve livelihood security. It is through such behaviour that pastoralists protected and promoted their entitlements during drought and thus the positive relationship between access to EWS information and access to pasture.

Results pertaining to early warning and availability of pasture as perceived by the community show that majority of the respondents (70%) indicated that they knew there was an EWS and were familiar with the early warning information activities through market behavior and changes reflected in pasture availability, livestock, goat, and fodder prices.

Table 4.21: Relationship between access to drought Early Warning Systems and pasture availability (Chi-Square Tests)

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	103.537[a]	4	.000
Likelihood Ratio	111.694	4	.000
Linear-by-Linear Association	5.934	1	.015
N of Valid Cases	373		

A drought Early Warning system managed by NDMA has been operating in the study area for more than 30 years. The study went further to determine whether access to climate related

disaster early warning systems affected the access to pasture and the findings are shown in table 4.16.

As shown in the table 4.21, the respondents were upbeat of the link between access to climate related disaster Early Warning Systems and corresponding access to pasture. In this regard, under no access to EWS information, 75 percent of the respondents had no access to pasture during droughts as compared to 25 percent who had access to pasture. With moderate access to EWS information, 48.1 percent of the respondents were able to access pasture while those with no access to information were 51.9 percent. It is also noted that with no access to EWS information, all the respondents (100%) reported that they could not access adequate pasture at all. The relationship between EWS information and access to pasture is shown in table 4.22. Table 4.23 shows the relationship between early warning system and information and access to pasture. These trends show the importance of EWS and information flow in enhancing access to pasture for pastoral communities in times of distress.

Table 4.22: Access to pasture and climate related disaster EWS Cross-tabulation

		Access to climate related disaster Early Warning Systems		
		No access	Moderate access	**Total access**
Access to pasture	No access	75.0%	25.0%	100%
	Moderate access	51.9%	48.1%	100%
	Adequate access	100.0%	0 %	100%

Table 4.23: Relationship between EWS information and access to pasture (Chi-Square Tests)

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.766[a]	2	.013
Likelihood Ratio	2.195	2	.034
Linear-by-Linear Association	.151	1	.008
N of Valid Cases	381		

As observed by Swidiq et al., (2013) an effective EWS must be able to trigger a timely response before the point of destitution is reached, to protect livelihoods before lives are threatened caused by reduced livestock pasture. Specific EWS focusing on particular livelihoods such as livestock have recently emerged to elicit livelihood-based responses to anticipated disasters in pastoral communities. Baudoin et al., (2014) observed that, development of effective EWS can foster livelihood resilience by improving coping mechanisms and even enhance adaptive capacity through better grazing management. Baudoin et al., (2014) explains that heightened awareness on access to pasture provides opportunities for risk preparedness and allows for community level adaption in the context of climate change. He adds that, in Turkana, with only one form of income, pastoralism, may have limited options for alternative livelihood sources during droughts, reflecting a critical need for early warning systems. Furthermore, types of EWS must be suited to the target community. Roger et al., (2014) agrees that due to the complex nature of droughts, a comprehensive and integrated approach that would consider numerous drought indicators is required for drought monitoring and early warning. Location-specific environmental changes (i.e. ecosystems changes, loss of biodiversity and habitats, land cover/land changes, coastal erosion, urban growth) become critical. Such early warning information is critical for decision making by nomadic pastoralists.

4.4.4 Relationship between access to technologies and quantity of livestock

So far it has been shown how drought conditions affect pastoralists' livelihoods, and in turn, how pastoralists respond to these conditions. The role of technology has not been mentioned yet. This study showed that generally speaking, technology can promote, help to protect, and provide easier ways for livestock rearing. The impact on pastoralists‘ economy and pastoralists coping behaviour offer several options and the results are illustrated in table 4.24. The relationship between access to technology and livestock ownership is indicated in table 4.25.

Table 4.24: Livestock Unit and access to mobile phones cross-tabulation

Livestock Units		Access to mobile phones		
		No access	Moderate access	Adequate access
	Below 20	52.2%	44.3%	3.5%
	21 to 40	41.3%	55.4%	3.3%
	41 to 60	47.2%	52.8%	
	61 and above	45.5%	50.9%	3.6%
Total		48.2%	48.7%	3.1%

The Chi-Square results indicated that access to technology has a strong positive linear relationship with number of livestock owned. This indicated that the more pastoralists have access to technology, the more livestock they will be able to keep. These findings agree with literature by Spies, (2011) who pointed out that agricultural development in the modern world is characterized by a transformation from an agrarian agriculture with a very high dependency on quality and quantity of natural resources to commercial agriculture which is more dependent on new technologies, quality of farmers and the availability of technological devices.

The study findings also concur with literature by Gonzalez, (2012) in which he evaluated the impact of ICTs interventions on livestock production. The study findings also agree with arguments by Kwadwo, (2012) that there is available evidence that ICTs can play a major role

in promoting livestock productivity and rural development by closing information gaps and reducing transaction costs, opening more opportunities for farmers in access to markets and empower smallholders. The study also borrows credence from Abdul, (2012) who observed that ICTs can also foster productivity by facilitating the dissemination of technological knowledge and expand access to financial and public services among the rural population by making service provision more affordable.

Table 4.25: Access to technology and livestock ownership

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.782[a]	6	.012
Likelihood Ratio	5.916	6	.03
Linear-by-Linear Association	.748	1	.017
N of Valid Cases	384		

The households who owned livestock could access technologies such as mobile phones, motorbikes and even afford to purchase cars.

4.5 Impact of drought on pastoral production systems - Objective Three

According to UNEP, (2011) Normal Drought Index (DI) is a measurement of dryness based on recent precipitation and temperature. The Percent of Normal is a simple method to detect droughts. It is calculated by dividing actual rainfall received in a normal season precipitation (average rainfall received in an area over time) typically a 30 - year mean and multiplied by 100 percent. Thus the Drought Index for Korr was 64 percent, Loglogo was 87 percent, Ngurunet was 74 percent and Laisamis was 53 percent. The Drought Index for the study area

was 53 percent. This implies that, the study area is likely to experience drought about 53 percent of the time. Rainfall figures in the study area are indicated in figures 4.8 - 4.11.

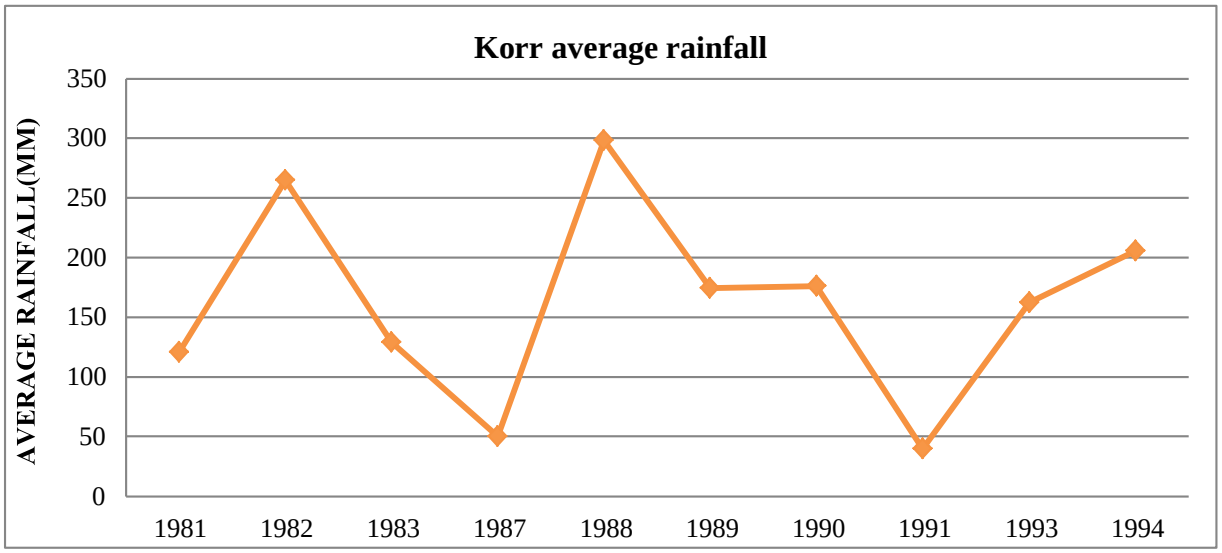

Figure 4.8: Korr average rainfall

In 1981, 1983, 1987, 1989, 1990, 1991, 1993, 1994 Korr experienced severe droughts. Over a period of 13 years, Korr experienced eight droughts indicating high community exposure to drought. This high exposure significantly contributes towards community vulnerability. Highest rainfalls were recorded in 1982 and 1988. A major challenge for the analyses is the availability of data for only 13 years.

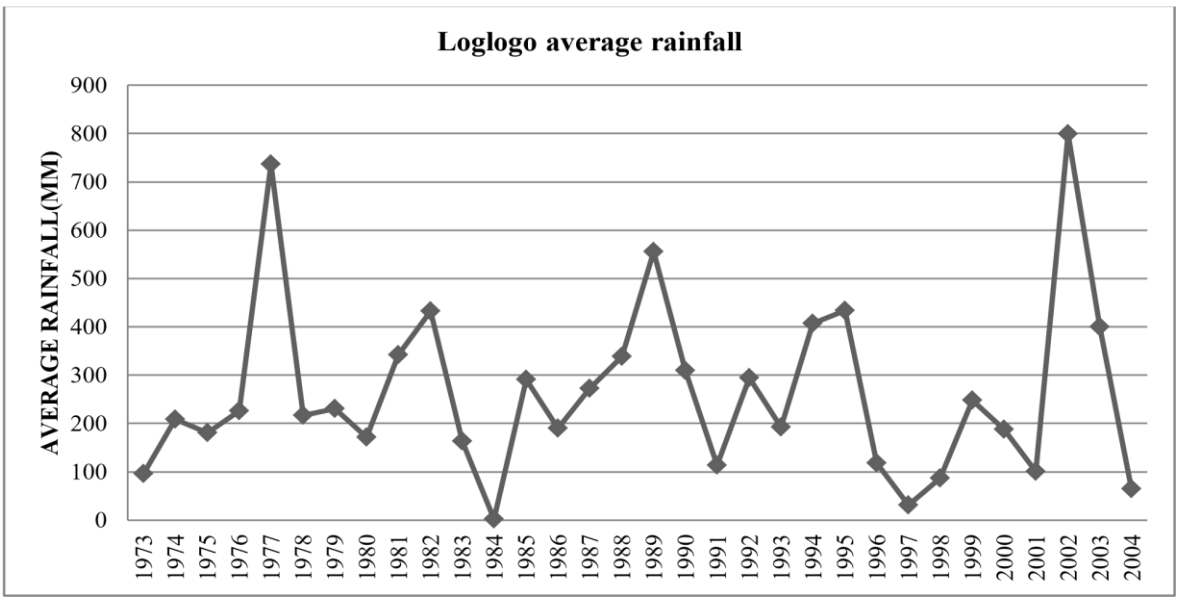

Figure 4.9: Log Logo average rainfall

In Loglogo, there are many variations in rainfall figures and apparently there are more years with less than 300 mm of rainfall including 1973, 1974, 1975, 1979, 1980, 1983, 1986, 1991, 1993, 1996, 1997, 1998, 2001 and 2004. The rainfall pattern for Loglogo indicates that the area experienced 14 major droughts over a 31 year period. This is an indication of the high *exposure* to drought.

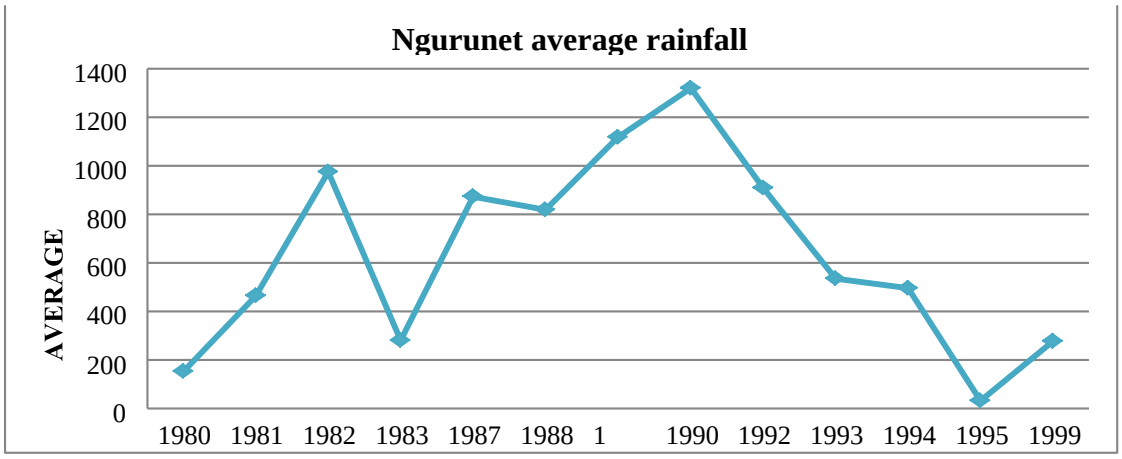

Figure 4.10: Ngurunet average rainfall

The average Annual average rainfall for Ngurunet is expected to be 600 mm per annum. However, the indication in the figure above is significantly showing low rainfalls in 1980, 1981, 1983, 1993, 1994, 1995, 1999. Severe droughts were experienced in 1980, 1983 and 1995. Highest rainfall was received in 1982, 1987, 1988, 1989, 1990 and 1992. From the 19 year rainfall records, it is clear that less than average rainfall was received exposing the community to droughts resulting in increased community vulnerabilities.

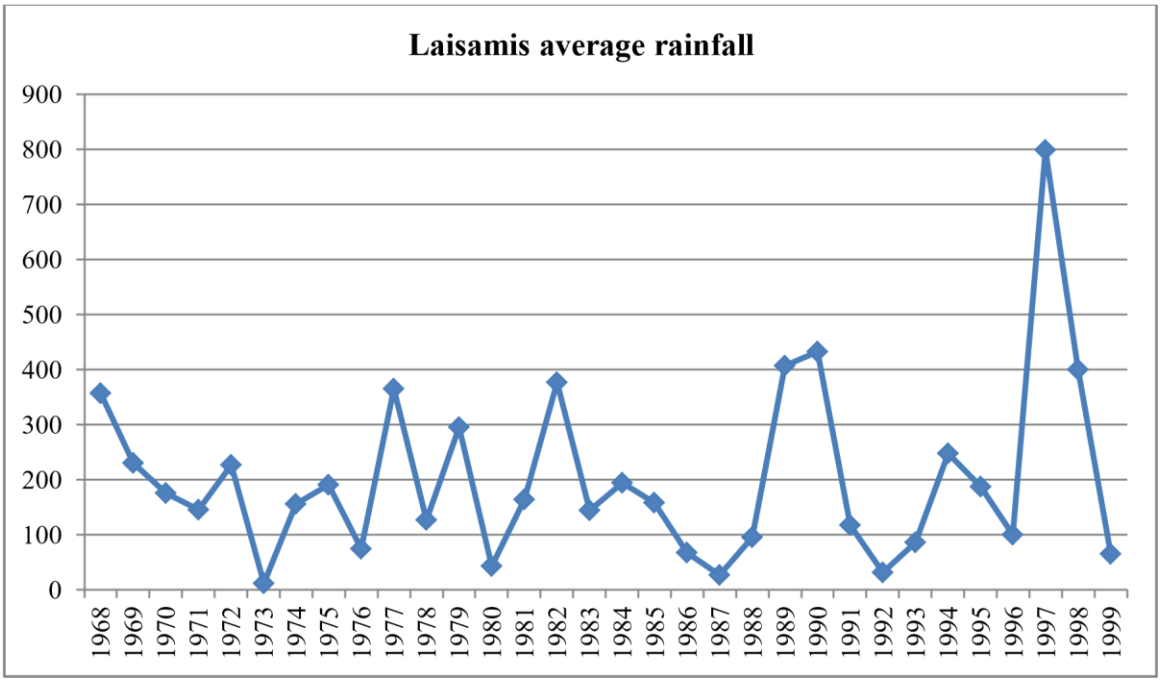

Figure 4.11: Laisamis average rainfall

The average Annual average rainfall for Laisamis is expected to be 400 mm per annum. However, from the 31 year record, 24 severe droughts were experienced in 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1978, 1980, 1981, 1983, 1984, 1985, 1986, 1987, 1988, 1991, 1992, 1993, 1994, 1995, 1996 and 1999. Highest rainfall was recorded in 1968, 1977, 1979, 1982, 1989, 1990 and 1997 and 1998. The Laisamis community is more *exposed* to frequent and severe drought than the other study sites. This implies that drought exposure significantly contributes towards vulnerability. Other factors considered under rainfall include length of long rains and short rains.

From the analysis above, Laisamis community is the most exposed to drought at 77.42 percent. The Laisamis community experienced 24 years of drought in 31 years. Korr community is exposed 61.54 percent. Korr community was exposed to 8 droughts over only a period of 13 years. Loglogo community is 45.17 percent exposed. Loglogo community was exposed to 14 droughts over a period of 31 years. While Ngurunet community was 36.85 percent exposed to drought. Ngurunet communities were exposed to 7 droughts over a 19 year period. The

percentages were used to allocate *exposure index* for the various locations i.e. *exposure index* for Laisamis was 0.8, Korr was 0.6, Loglogo was 0.5 and Ngurunet was 0.4. The lowest exposure index is 0, while the highest is 1. Korr, Laisamis, Ngurunet and Loglogo had no manned meteorological stations. Therefore there were challenges in obtaining consisted data from the study area.

From disaster records nationally, in the National Policy for Disaster Management, (2009), in 1975, 1977, 1980, 1983/1984, there were widespread droughts in Kenya that affected 20,000, 40,000, 4,000 and 200,000 persons respectively. In 1995/1996, there was widespread drought that affected 1.4 million persons nationally. The El Nino floods of 1997/1998 were widespread and affected 1.5 persons nationally. In 1999/2000, there was a major drought in the country that affected 4.4 million persons. In 2004, the country experienced widespread drought that affected 3 million persons needing relief food for a period of eight months. In 2006, there were floods in Laisamis that displaced 5,000 persons.

In California and North Carolina (USA), Hao et al., (2013) used a multivariate, multi-index drought-modeling approach. The model, named Multivariate Standardized Drought Index (MSDI) probabilistically combines the Standardized Precipitation Index (SPI) and the Standardized Soil Moisture Index (SSI) for drought characterization. In other words, MSDI incorporates the meteorological and agricultural drought conditions for overall characterization of drought. In South Gobi, Mongolia, Sterbberg et al., (2009) observed that low precipitation and high climatic variability in this dry land environment impacted the landscape and affected pastoralism, the dominant rural lifestyle. Using the SPI, they identified drought occurrence in South Gobi Province, Mongolia. It then examined the relationship of drought with climate factors, interaction with vegetation (derived from Normalised Difference Vegetation Index - NDVI - data), and local human and livestock populations and found that drought is recurrent

in the region, reaching extreme intensity most in 2005–2006. In Turkana, Kenya, Opiyo et al., (2015) used the SPI derived from long-term rainfall data obtained from the Kenya Meteorological Service to quantify different degrees of drought intensity between 1950 and 2012 and found that extreme drought events were increasingly frequent, and have impacted negatively on pastoral livelihoods.

4.5.1 Relationship between drought index and number of livestock owned

The relationship between drought index and number of livestock owned is important in determining the impact of drought on pastoralists. The correlation is illustrated in table 4.26.

Table 4.26 Relationship between drought index and number of livestock owned

		Drought Index
Livestock Unit	Pearson Correlation (r)	-.093
	Sig. (2-tailed)	.095
	N	321

There is a weak negative (r=-0.093, p= 0.095) linear relationship between drought index and number of livestock owned. This means that for every increase in drought index, there is a decrease in the number of livestock owned. This finding echoes literature by Seo and Mendelsohn, (2016) who argued that the probability of owning livestock decreases as annual temperature increases and annual rainfall decreases. Seo and Mendelsohn, (2016) explained that as the temperature rises, pastoralists prefer to own goats and sheep rather than beef cattle and dairy cattle which all decrease in numbers as precipitation decreases. All three of these species are more productive in grasslands. In contrast, goats and chickens are more likely to be chosen as rain decreases.

The findings are also supported by Kabubo-Mariara, (2011) who established that the effect of drought on net animal revenue on those who own large number of livestock shows a linear increase. The weak linear relationship can be explained by the argument of Digambar, (2011) that those who own a small number of livestock are not affected much during the drought season. The weak relationship is linked to the fact that during rainy season, farmers shift to crops since there is limited rainfall and availability of natural grazing for most animals as well as increase in animal diseases notes Seo and Mendelsohn, (2016). The weak relationship can also be explained from findings by FAO, (2012) that as high temperatures and changes in rainfall patterns occur, there is increase and spread of existing vector-borne diseases and micro parasites of animals as well as the emergence and spread of new diseases.

Similar findings by Abate, (2013) show that drought and delay in the onset of rain led to poor regeneration of grass, water shortage and heat stress on livestock as well as increased mortality of livestock, vulnerability to diseases and physical deterioration due to long distance travel in search of water and pasture. As a result of severe drought, there was direct impact on the growth of palatable grass species and that regeneration of fodder decreased because of less rainfall leading to forage shortage in diversity and quality of livestock fodder observes Digambar, 2011). Therefore, from the findings of this study, it can be argued that increase in drought index leads to a decrease in livestock population which affects production of milk, milk products, meat and increases vulnerability of the population. Drought also affects livestock by drying of wetlands, pasture land, water resources, streams and decreased availability of drinking water for domestic and livestock use.

4.5.2 Relationship between drought index and availability of pasture (percentage cover)

The relationship between drought index and pasture availability significantly contributes towards drought impact as described in table 4.27.

Table 4.27: Relationship between drought index and available pasture (percentage cover)

		Drought Index
Pasture Cover	Pearson Chi-square	19.110
	Asymp. Sig. (2-sided)	0.002
	Cramer's V	0.134
	Df	1
	Cohen‘s Index(w)	0.134

The Chi square results indicated that there is a significant relationship between Drought Index and availability of pasture. X2 (1) =19.110, p=0.002. With reference to the chi-square test, it was interpreted that the relationship between drought index and availability of pasture in the study area is low, w=0.134.

The assessment of drought index and availability of pasture in this study, supports findings by Wilhite, (2014) and Wilhelmi, (2012) that drought reduces pasture availability due to exposure to the climatic hazard and the underlying dryness primarily leads to low pasture availability. It also reinforces findings by Smith, (2016) in which he established that high drought index will decrease availability of pasture. However, Semenza and Menne, (2009) established a different reason explaining the relationship between drought index and availability of pasture. They indicated that differences in pasture availability due to drought may also be due to overgrazing. This can however be managed by taking actions such as planning and decision making on longer timeframes, with the objective to enhance resilience by planning (risks & exposure), infrastructure and protection of strategic reserves requiring community involvement and support as proposed by AfriCAN Climate, (2015). Unfortunately, traditional pastoral mobility has been restricted by loss of pastoral lands to population pressures (of both humans and livestock), encroachment on important grazing areas by expanding agricultural or other

pastoral groups, as well as the creation of commercial ranches and game parks observes Fratkin et al., (2004).

4.5.3 Relationship between drought index and number of water bodies

Number of water bodies and distribution in pastoral areas play a significant role in determining impact of drought on pastoralists especially if the water bodies are strategically located. The relationship between water bodies and drought index is illustrated in table 4.28.

Table 4.28: Relationship between drought index and number of water bodies

Correlations

		Main Source of Water
Drought Index	Pearson Correlation (r)	-.002
	Sig. (2-tailed)	.968
	N	310

From table 4.28, there is a weak negative (r=-0.002, p= 0.968) linear relationship between drought index and number of water sources. This means that for every increase in drought index, there is a slight decrease in the number of water sources.

The weak negative relationship can be explained from available literature by Waggoner and Revelle, (2010) that drought is an instrumental factor that affects water quality, both for surface as well as ground water. They continue to explain that drought reduces water quantity which results in changes in flow regimes influencing the chemistry, hydro-morphology and ecology of regulated water bodies. The weak relationship is linked to the fact that communities take measures to reduce the effects of drought by constructing new water sources such as dams, pans and boreholes as observe by Whitehead, (2015). However, generally, the study findings show that water bodies that play an important role dry up during such heat events and longer

evaporative seasons hence the negative relationship. Increased drought index as per Murdoch, Baron and Miller, (2014) leads to lowering underground water table and hence lowers the number of water bodies available as it also leads to changes in water quality elevated air temperature or drought can cause conditions that exceed thresholds leading to water quality degradation.

Taylor, (2013) established that water quantity under climate extremes are affected through reductions in the water stored in glaciers and snow cover that keep on declining under extreme weather conditions. This trend reduces water availability especially during warm and dry periods

(through a seasonal shift in stream flow, an increase in the ratio of winter to annual flows, and reductions in low flows) in regions supplied by this source explain Taylor, (2013). Delpla, (2011) adds that water availability from water bodies decreases further when storage capacities are not sufficient as much of the winter runoff will be lost to the oceans, and this will create regional water shortages hence the negative relationship. In many cases, access to large scale water developments have turned out to be destructive on the environment and has contributed to increased vulnerability of pastoralists to drought observes Manger, et al., (2000).

4.5.4 Relationship between drought index and number of livestock species

Number of livestock species play significant role in determining impact of drought on pastoralists because various livestock species have varied tolerance and adaption to drought. For example, camels, goats and donkeys are better adapted to drought than cattle and sheep. The relationship between drought index and number of livestock species is illustrated in table 4.29.

Table 4.29: Relationship between drought index and number of livestock species

		Cattle	Camels	Goats	Sheep
Drought Index	Pearson Correlation	-.249	.023	.035	.056
	Sig. (2-tailed)	.000	.684	.538	.325
	N	312	312	312	312

From table 4.24, there is a weak negative (r=-0.2492, p= 0.968) linear relationship between drought index cattle as well as camels (r=0.023), goats (r=0.035) and for sheep (r=0.056). This means that for every increase in drought index, there is a decrease in the number cattle owned and little increase in number of other species including camels, goats and sheep.

These findings concur with UNEP, (2012) that generally population of livestock species decreases due to drought. The credence of the study findings can also be found from findings by Thomas, (2014) that drought eliminates 15 percent to 37 percent of all species in the world. Steinfeld, (2016) explains this by arguing that increase in temperature affects species reproduction, migration, mortality, and distribution.

The decrease of cattle in number as drought index increases is explained by Thornton, (2011) who states that loss in livestock species is mainly because of practices used in livestock production that emphasize yield and economic returns and marginalization of traditional production systems where other considerations are also important (such as ability to withstand extremes).

4.5.5 Relationship between drought index and livestock prices

Since livestock is the main livelihood for the pastoralists and they have to sell their livestock to support themselves in access to their basic needs including food, shelter, medical and other

social needs. Livestock prices contribute either positively impact during good rainy seasons or negatively impact during drought periods. The relationship between drought index and livestock prices is demonstrated in table 4.30.

Table 4.30: Relationship between drought index and livestock prices

		Livestock Prices
Drought Index	Pearson Correlation (r)	-.148
	Sig. (2-tailed)	.008
	N	321

From table 4.30, there is a weak negative (r=-0.148, p= 0.008) linear relationship between drought index and prices of livestock. This means that for every increase in drought index, there is a decrease in the prices of the livestock. The findings augment by scholars like Paarlberg and Lee, (2016) that effects of drought can persist for several years in the livestock industry and as feed costs rise, livestock producers typically increase livestock slaughter increasing supply thus lowering prices. The weak relationship can be attributed to the fact that the rise in supply of livestock causes the price of live livestock to decrease in the short-run and beef livestock inventories to decrease in the long-run. Livestock industries usually take longer to recover than crop industries do because of the drought-induced decrease in breeding stock. The study established from responses from key informants that livestock slaughter rises at the onset of a drought, but then diminishes below baseline levels and remains low until producers build up the breeding stock again. Conversely, the price of livestock declines as the market is flooded with low-weight livestock and culled livestock. After slaughter declines, the prices rise above baseline and slowly work back down as breeding stock and slaughter rise again.

The fluctuation of livestock prices as per the study findings have also been explained by Wilson, (2017) when he explains that drought is an important market factor in livestock industry. Prices may reduce by upto 70% for all livestock species including camels, cattle, sheep and goats during a severe drought. The findings can also be explained by Wilson, (2017) that with short supplies of hay available, livestock herds get reduced, resulting in slaughter prices being the lowest. Cattle and sheep generally consume green grass as their main diet. Hay from wheat stems and other plant material is used as a nutritional supplement. As the drought persists, supplies of hay continue to run low and the prices of hay continue to rise. Consequently, farmers put a lot more cattle on the market as they could not feed them due to the drought and hence the cattle prices come down observe, Wilson, (2017).

Drought reduces crop production which increases commodity prices by upto 50%. Higher commodity prices increase feed costs which induce reductions in livestock breeding. Drought also induces greater cattle slaughter which puts downward pressure on cattle prices and accelerates the breeding herd reduction. As forage prices rise, other crop prices rise as well observes, Sivakumar, (2011). Changes in crop prices alter input costs for livestock. Forage and pasture, along with grains, are the crops with the largest impact on costs in the beef sector as they comprise the largest percentage of beef cattle feed. Drought also leads to culling of breeding animals and further increased cattle slaughter. Increased slaughter affected cattle prices in the short run. Reduced cattle prices and higher feed costs reduce lead to lower returns throughout the supply chain leading to a decrease in beef cattle supply and a corresponding decrease in the supply of calves moving through the supply chain over time, which affects cattle prices in the long run.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives the summary of findings, conclusions and recommendations of the study. It is divided into four parts, the first part gives the summary of the findings for each objective, the second part gives the conclusions and practical application in real world and the third part provides recommendations based on conclusions and the final part gives suggestions for further research.

5.2 Summary of Findings

About 65.1 percent of households in the study were found to be Vulnerable with the Vulnerability Index being 0.0 to 0.49. 32 .6 percent of the households were Moderately Vulnerable with 0.5 - 0.69 Vulnerability Index. Only 2.3 percent of households were Highly Vulnerable with Vulnerability Index of 0.7 - 1.0. Various aspects were measured in relation to how they rate at different levels of vulnerability. These aspects included, number of livestock owned, prices of livestock, availability of pasture, number of water bodies accessed, numbers of livestock owned and livestock species diversification.

The study established a weak negative (r=-0.010, p= 0.02) linear relationship between vulnerability index and number of livestock owned implying a decrease in vulnerability as livestock numbers increased. However, the relationship is weak and negative owing to the increase in livestock numbers by a reducing margin as human population owning the livestock increases.

Regarding how vulnerability affects livestock prices, the study established that a weak negative (r=-0.006, p= 0.01) linear relationship between Vulnerability index and prices of the livestock.

This implied that at low vulnerability levels, livestock prices were higher. According to this study, this negative relationship is due to the fact that goods are valued based on their attributes and vulnerability caused by climatic changes affect livestock attributes such as condition and size that affect the prices.

Effect of availability of pasture on vulnerability was found to be medium and significant w=0.455. This was due to four main factors being: the impact of changes on livestock feed-grain availability and price; the impact on livestock pastures and forage crop production and quality; changes in livestock diseases and pests; and the direct effects of weather and extreme events on animal health, growth and reproduction.

Number of water bodies were found to reduce the vulnerability levels as indicated by a negative relationship (r=-0.256, p= 0.00). The weak negative relationship was due to the fact that most water bodies are developed due to increased vulnerability which brings the aspect of cause and effect. Regarding the relationship between livestock species diversification and vulnerability index, the study found that new breed including Turkana camels and Galla goats that are drought tolerant and consume less pasture are now being reared by pastoralists in Marsabit. New breeds of such as Galla goats and sheep consume less forage when compared to cattle and produce nutritious milk which is preferred by consumers. The indigenous livestock breeds, including the Rendile camels, Small East Africa Goat, Zebu and Boran breeds are also reared by the communities in the study area. The study determined that this reduces vulnerability in rapid population growth rate scenario. However, the study found that different livestock species had different effect on drought vulnerability. For instance, cattle numbers indicated as weak positive (r=0.017, p= 0.747) linear relationship with vulnerability index, same as for sheep (r=0.011, p= 0.840) and donkeys (r=0.100, p= 0.059). This implied that for every increase in

the number of these species, there is an increase in vulnerability index. On the contrary, there is a weak negative (r=-0.039, p= 0.459) linear relationship between Vulnerability index and the number of camels owned same as for goats (r=-0.025, p= 0.632) which meant that for every increase in the number of camels and goats, there is a decrease in vulnerability index.

The main adaptation options to drought practiced by the communities in Marsabit County were found to be based on communities taking considerable changes in livestock population, herd composition and management systems with different predominance of livestock species. The changes in herd composition such as selling of breeding bulls, are determined by income levels from livestock and market demand for livestock and its products in general. Some of the aspects of adaption determined included; access to drought early warning systems and access to technologies. The study determined that early warning systems have led to increased access to water for the communities through community preparedness for droughts ensuring that water is available from water pans, boreholes and springs. The study also established that there is a significant positive relationship between access to EWS information and access to pasture. Access to technologies was found to have a significant relationship to the number of livestock owned due to the ability of technologies in promoting, helping to protect, and provide effective ways for livestock rearing.

Impact of drought on pastoral production systems was measured using the relationship between various factors in relation to the drought index in the study area. The factors considered in the study were, relationship between drought index and number of livestock owned, availability of pasture, number of water bodies, number of livestock species as well as livestock prices.

The study established that there is a weak negative (r=-0.093, p= 0.095) linear relationship between drought index and number of livestock owned. There was also a significant

relationship between Vulnerability Index and availability of pasture X2 (1) =19.110, p=0.002 which was however low w=0.134.

The study determined that there is a weak negative (r=-0.002, p= 0.968) linear relationship between drought index and number of water sources. There was however a differing relationships between drought index and livestock species indicating, a weak negative (r=0.2492, p= 0.968) linear relationship between drought index and cattle, a weak positive linear relationship between drought index and camels (r=0.23) same as for goats (r=0.35) and for sheep (r=0.56). This means that for every increase in drought index, there is a decrease in the number cattle owned and little increase in number of other species being camels, goats and sheep.

5.3 Conclusion

The livestock in arid areas of Kenya plays a significant role in the local economies of such areas with many rural Kenyans deriving a range of financial benefits from livestock keeping. Livestock owners often cash in their animals for particular purposes at a time of need and choice which highly determines the levels of vulnerability for such communities. Since pastoralists hold most of their wealth in form of livestock, the effects of climate variability including drought and related challenges affect their entire livelihoods. Given the critical role livestock plays in the lives of the pastoralist communities, there still exists a myriad of constraints emanating from different areas of concern some of which have been highlighted in this study.

First, communities will reduce the number of livestock owned at times of high vulnerability through selling off some livestock. However, majority of the pastoralists do not sell off their animals hoping it will rain soon and in the process of waiting, more animals die

Vulnerability also negatively affects livestock prices, making livestock prices fall at times of high vulnerabilities. The negative effect is caused by livestock attributes and vulnerability caused by climatic variability that affect livestock attributes such as condition and size.

Secondly, vulnerability is high when there is low availability of pasture which increases stress levels of the communities as livestock feed-grain availability becomes scarce and price rise. There is high and negative impact on livestock pastures and forage crop production during times of drought. Prevalence of livestock diseases, pests and the direct effects of weather and extreme events on animal health, growth and reproduction are experienced during droughts.

Third, number of water bodies was found to reduce the vulnerability levels of communities, though by a small margin. The study also concludes that rearing of new breeds that are drought tolerant and consume less pasture would reduce vulnerabilities of communities in Marsabit County. Key of these species are camels, donkeys and goats.

The study concludes that the key adaption strategies to be stressed are access to drought early warning systems and access to technologies. The benefits of access to early warning systems is among other factors leading to increased access to water for the communities through community preparedness for droughts as well as improved access to pasture. Access to technologies would promote, protect, and provide innovate and efficient ways for livestock production. Though, the results of the study are specific to Laisamis Sub-County, Marsabit County, Kenya, the approach and the findings are applicable to other arid and semi-arid

pastoral production systems in the region and the globe. Identifying factors to be addressed and in what way, and the subsequent designing of adaptation measures builds on the understanding of vulnerability and capacity. Because adaptation is a process with no definite end point, since what we are adapting to is constantly changing, there never is an absolute conclusion, MRC, (2010).

5.4 Recommendations

Based on the study findings majority of households are Vulnerable with a Drought Vulnerability Index of 0.49. This implies that, the communities in the study area are resilient to drought and therefore minimum external interventions are necessary. External interventions may lead to undermining of community resilience and create dependency on external support. Since the households are highly dependent on rain-fed pasture production, there is need to invest in drought early warning systems, development of additional water sources and investment in irrigated pasture production. Rainfall is low and unreliable and even the low rainfall data cannot be obtained due to lack of manned weather stations in the study area. Therefore, the study recommends establishment of weather stations at strategic locations in Loglogo, Korr, Laisamis and Ngurunet. The weather stations may record rainfall and temperature as a bare minimum and support the community in drought early warning, drought preparedness and drought mitigation.

Communities are exposed to frequent droughts situations. Inorder to adapt to droughts situations, households need to keep more drought tolerant livestock like camels and engage in non-drought sensitive livelihoods, for example trade, where possible. As a short-term drought coping strategy, only 7 percent came from external sources. 93 percent of drought coping strategy originated from within household and community resources. This implies that,

external supporters need to provide low inputs and take precautions not to undermine indigenous drought coping and adaptation mechanism within the households. Livestock ownership and herd distribution is an important livelihood strategy among the community in the study area. Some households had few livestock, while others kept camels, cattle, sheep, goats and donkeys. There is need to support the households with few or no livestock through a restocking programmer. The households, with livestock need to be encouraged to keep more drought tolerant livestock like camels. Livestock mobility significantly contributes to drought resilience to communities in pastoral systems. This practice needs to be encouraged and peace building be enhanced with neighboring communities to facilitate movements and access to grazing and water resources especially during drought periods.

The impact of drought among pastoral communities normally manifests itself in the form of livestock losses, which adversely affects the provision of subsistence, income, and other socioeconomic services to pastoral households. These calls for livestock diversity and the households need to be encouraged to invest more in camels, donkeys and goats due to their tolerance to drought and efficient utilisation of livestock forage including browse and grazing. This is due to browse habits of camels and goats while sheep and cattle are mainly grazers.

Since households mainly depended on shifting from place to place, as a drought coping mechanism, insecurity or conflicts needs to be minimized to enhance livestock and human mobility in the study area and beyond. Peace building and conflict prevention initiatives are necessary. This will ensure that there is minimum or reduced impact of drought to highly mobile communities in search of pasture and livestock forage.

5.5 Areas for further research

More research is required to generate more understanding of drought vulnerabilities, adaptation options and impacts in arid environments. Future suggested research area may include the following areas:

1. The research focused on the components of Vulnerability Index including Exposure, Sensitivity and Adaptive Capacity. Further in-depth research is necessary on the individual components to understand each factor comprehensively i.e. Exposure, Sensitivity, Adaptive Capacity and Adaptation Options.
2. Other disasters that affect pastoral communities including floods, conflicts, livestock and human diseases need further studies and documentation.
3. Because of remoteness, there are no similar studies conducted in the study area. Researchers and development organisastions need to be proactive in conducting similar research to validate or provide additional new information on drought vulnerability.

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APPENDICES

Appendix I: Magnitude of Drought Vulnerability Assessment
Instructions:
Please tick or fill gap where appropriate
Geographic Information
Introduction
My name is:.....(Name of enumerator)
I am collecting data for a PhD student at Maseno University.
The purpose of the survey is to enable the student to analyse drought vulnerability in Laisamis Sub-County.
The data and the results of the analysis will be shared with development partners for better targeting during drought intervention.
Your responses will be confidential and will not be shared.

Question	**Response**
Serial number	
Date of interview [dd/mm/yyyy]	
County	
Sub-County	
Location	
Sub-location	
Village/settlement name	
Enumeration area (EA)	☐ EA1 ☐ EA2 ☐ EA3
	☐ EA34
Name of respondent	
Office use only	
Completed questionnaire (Supervisor Approval)	☐ Yes ☐ No
Household back-checked?	☐ Yes ☐ No
Data entry clerk‘s name	

Consent request
Hello, my name is…….....I am part of a team from Maseno University carrying out a survey on Assessment of drought Vulnerability, adaptation options and impact among pastoralist systems in Marsabit County, Northern Kenya for a PhD study. Your household is

among the ones identified for this exercise. I would like to ask you some few questions concerning your household. This interview is expected to last 15 to 20 minutes. Whatever information you provide will be kept confidential and will not be shared with anyone who is not part of this exercise without your consent.

Give card with contact information to the respondent

Do you have any questions concerning the survey?

May I begin the interview now?

Section A: Demographic Information of the respondents

	Question	**Response**
A1	Gender	☐Male ☐Female
A2	Age	…….
A3	Highest level of education attained	☐No formal education ☐Primary education ☐Secondary education ☐Tertiary/college education ☐University Education ☐Others (Specify)……. …….
A5	What do you do for a living?	☐Employed ☐Self employed ☐Unemployed ☐Student ☐Others (specify)…… ……
A6	What is your average monthly income/Wage?	☐Less than Ksh 5,000 ☐5,001-10,000 ☐Above 10,001

Section B: Sensitivity Indicators (Human/ Social System Indicators)

	Question	**Response**
B1	What is the size of your household? (RECORD THE NUMBER)	Male …….. Female……...
B2	Total number in age categories. (RECORD THE NUMBER)	Under five years…… 6-18 Years……. 19-64 Years …… Above 65 years……
B3	Has any member of your household **suffered sickness** related to **drought**?	☐ YES ☐ NO ☐ N/A
B4	Have you **lost** any of your household due to **drought**? IF YES HOW MANY? (RECORD THE NUMBER) …….	☐ YES ☐ NO ☐ N/A
B5	Has any member of your household **suffered sickness** related to **floods**?	☐ YES ☐ NO ☐ N/A
B6	Have you **lost** any of your household due to **floods**? IF YES HOW MANY? (RECORD THE NUMBER) …….	☐ YES ☐ NO ☐ N/A
B7	Do you have livestock? IF NO SKIP TO B11	☐ YES ☐ NO

Livestock	**B8** (Record the total number)	**B9** Have you **lost** any of your household due to **drought**? (Record the total number)	**B10** Have your livestock **been sick due** to **floods**? (Record the total number)
Cattle			
Camels			
Goats			
Sheep			
Donkeys			

	Question	Response	For office use only (Vulnerability Index)
B11	Do you have access to adequate water for domestic use? IF NO SKIP TO B15	☐ YES ☐ NO	
B12	What is the main source of water for domestic use?	☐Surface rain water ☐Water pan/Dam ☐Borehole ☐Shallow well ☐Others (specify)……	
		……	
B13	Is the water source reliable throughout the year?	☐ YES ☐ NO	
B14	What is the distance to the water source?	☐Less than I km ☐2-3 km ☐4-5 km ☐More than 6 km	
B15	Do you have access to adequate water for livestock? IF NO SKIP TO B17	☐ YES ☐ NO	
B16	What is the distance to the water source?	☐Less than I km ☐2-3 km ☐4-5 km ☐More than 6 km	
B17	What are the common diseases related to water shortage? (LIST AT LEAST 3)	A…… B…… C…… D……	
B18	IS THE SOIL SUSCEPTIBLE TO EROSION?	☐ YES ☐ NO	
B19	IS THE LAND DEGRADABLE?	☐ YES	

		☐ NO	
B20	IS THERE POPULATION PRESSURE ON THE NATURAL RESOURCES?	☐ YES ☐ NO	
B 21	What is the topography of the area?	☐ Flat land ☐ Gentle topography ☐ Hilly area	1. - 0.3 0.4 - 0.6 0.7 - 1.0
B22	What is the source of energy for cooking?	☐Firewood ☐Charcoal ☐Gas ☐Electricity ☐Others (specify)……	
	a. Is the energy source reliable?	☐ YES ☐ NO	
	How much do you pay for energy monthly?	☐Less than Ksh 5,000 ☐5,001-10,000 ☐More than 10,001	
B23	What is the source of energy for cooking?	☐Firewood ☐Solar ☐kerosene ☐Electricity	
		☐Others (specify)……	
	a. Is the energy source reliable?	☐ YES ☐ NO	
	How much do you pay for energy monthly?	☐Less than Ksh 5,000 ☐5,001-10,000 ☐More than 10,001	

Section C: Drought vulnerabilities - Exposure (Humans, Livestock, Vegetation and water resources)

	Question	**Response**	**For office use only (Vulnerability Index)**
C 1	Do you receive adequate rainfall? IF NO SKIP TO B 7	☐ YES ☐ NO	

C 2	Does it rain normally or in storms?	☐ Normal ☐ Storms	
C 3	How long are the short rainy seasons	☐ 0-1 Months ☐ 2-3 Months ☐ More than 4 months	0.0- 0.3 0.4 -0.6 0.7 -1.0
C 4	How long are the Long rainy seasons	☐ 0-1 Months ☐ 2-3 Months ☐ More than 4 months	0.0- 0.3 0.4 - 0.6 0.7 - 1.0

C 5	How long are the dry seasons after the long rains?	☐ 0-1 Months ☐ 2-3 Months ☐ More than 4 months	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
C 6	How long are the dry seasons after the Short rains?	☐ 0-1 Months ☐ 2-3 Months ☐ More than 4 months	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
C 7	How frequent are the droughts?	☐Once in a year ☐Every 2 years ☐Every 3-5 years ☐Every 6-10 years ☐More than 11 years	1. - 0.2 3. -0.4 5. -0.6 7. -0.8 0.9 -1.0
C 8	How frequent are the floods?	☐Once in a year ☐Every 2 years ☐Every 3-5 years ☐Every 6-10 years ☐More than 11 years	0.1 - 0.2 4. -0.4 6. -0.6 8. -0.8 0.9 -1.0
C 9	How frequent are the Hailstones?	☐Once in a year ☐Every 2 years ☐Every 3-5 years ☐Every 6-10 years ☐More than 11 years	0.1– 0.2 5. -0.4 7. -0.6 9. -0.8 0.9 -1.0
C 10	How did you cope with the droughts?	☐Shifted to another site ☐Sold off the livestock	

		☐Had some cash savings ☐Received remittances ☐Received famine relief ☐Others (specify)	
C 11	Name five desirable plant species	1…….. 2……...	

		3…… 4…… 5……	
C 12	Name five undesirable plant species	1…… 2…… 3…… 4…… 5……	
C 13	Do you experience fire in your area/community? IF NO SKIP TO 15	☐Yes ☐No	
C 14	Fire frequency	☐Once in a year ☐Twice in a year ☐Once in two years ☐Once in 3 years ☐Once in more than 5 years	
		☐Others (specify)	
C 15	a. Presence of wildlife? predators	☐Yes ☐No	
	Presence of wildlife forage competitors IF NO SKIP TO 17	☐Yes ☐No	
C 16	Name five common wildlife species	1…… 2…… 3…… 4…… 5……	
C 17	Is your home in conflict (human conflict) zones?	☐Yes ☐No	
C18	How frequent are they?	☐Once in a year ☐Twice in a year ☐Once in two years ☐Once in 3 years ☐Once in more than 5 years ☐Others (specify)	

Section D: Adaptive capacities indicators

	Question	Response	For office use only
			(Vulnerability Index)
D1	Do you access to pasture?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
D2	Do you own productive assets? IF NO SKIP TO D4	☐Yes ☐No	
	a. IF YES INDICATE the type of asset	☐Business …… ☐Other income generating activities …… …… ……..	
D3	What is the monthly income from the asset?	☐Less than Ksh 5,000 ☐5,001-10,000 ☐More than 10,001	
D4	Do you receive remittances from relatives?	☐Yes ☐No	
	a. IF YES how much per month?	☐Less than Ksh 5,000 ☐5,001-10,000 ☐More than 10,001	
D5	Do you have access to technological alternatives to improve your productivity?	☐Yes ☐No	
	a. IF YES which ones? LIST THE TECHNOLOGIES	1…… 2…… 3…… 4…… 5…….	
D6	Are you food self-sufficient?	☐Yes ☐No	
	a. IF YES how many months were you/do you have?	Food deficit ……. Adequate food	

		…… Surplus food ……	
D7	What are the typical food components for a month?	☐Meat ☐Milk ☐Maize ☐Wheat ☐Rice ☐Others (specify) …… ……	
D8	How much do you spend on food in a month?	☐Less than Ksh 5,000 ☐5,001-10,000	
		☐More than 10,001	
D9	Do you live on your own house or rented house or housed by the employer?	☐Own house ☐ Rented house ☐Housed by the employer ☐Others (specify) …… ……	
	a. WHAT TYPE OF HOUSE DO YOU HAVE (OBSERVE ONLY)	☐Mobile huts ☐Semi permanent ☐Permanent	
	b. IF RENTED how much do you pay monthly?	☐Less than Ksh 5,000 ☐5,001-10,000 ☐More than 10,001	
D10	What social network do you have? (MULTIPLE RESPONSES ALLOWED)	☐Men‘s groups ☐ women‘s groups ☐Community cooperatives ☐Community welfare groups ☐Merry go rounds ☐Barazas ☐Others (specify) ……	
D11	How do you rate your political representation?	☐Well represented ☐Moderately represented	0.0- 0.3 0.4 - 0.6
		☐Marginalized	0.7 - 1.0

D12	Do you have access to climate related disaster early warning systems?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
D13	Do you have access to information on livelihoods support initiatives (Veterinary services, marketing?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
D14	Do you have crisis management programs contingency plans (for drought and other disasters)?	☐Yes ☐No	
	a. IF YES which ones?	1…… 2…… 3…… 4…… 5…….	
D15	How often do you move your livestock?	☐No mobility ☐2 -3 times in a year ☐More than 3 times a year	0.0- 0.3 0.4 -0.6 0.7 -1.0
D16	How often do you move your household?	☐No mobility ☐2 -3 times in a year ☐More than 3 times a year	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
D17	Do you have access to good roads to the nearby major town?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 -0.6 0.7 -1.0
D18	Do you have access to reliable public transport?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 -0.6 0.7 -1.0
D19	Is there a medical facility nearby?	☐Yes ☐No	
	a. IF YES list which one	1…… 2…… 3……	
	b. IF YES Does the medical facility mentioned above have adequate medical supplies?	☐Yes ☐No	
	IF YES Does the facility have competent medical staff?	☐Yes ☐No	

Section E: Adaptation options

	Question	**Response**	**For office use only (Vulnerability Index)**
E1	What are your current adaptation practices in relation to floods and droughts? (LIST ATLEAST 3)	1…… …… …... 2…… …… …… 3…… ……	

		……	
E2	Do you access to mobile phones?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
E3	Do you access to internet?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 -0.6 0.7 -1.0

E4	Do you access to credit facilities?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
E5	Do you access to extension services?	☐No access ☐Moderate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0

		☐Adequate access	
E6	Do you access to livestock veterinary supplies?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
E7	Do you access to marketing information?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
E8	Do you access to marketing infrastructure?	☐No access ☐Moderate access ☐Adequate access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
E9	Do you access to climate change related disaster insurance facilities?	☐No access	0.0- 0.3 0.4 - 0.6 0.7 - 1.0
		☐Moderate access ☐Adequate access	

E10	How do you sell your livestock currently?	☐Informal trade ☐Through middlemen ☐Through a cooperative ☐Others (specify) ……..	
E11	What can you recommend as options for adaptations to climate change to other pastoralists? 1…… 2…… 3…… 4……5…… ……		

Comments

……
……
……
……

APPENDIX II: RESEARCH AUTHORIZATION

Appendix II

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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Ref: No. NACOSTI/P/15/98760/8720

Date: 2nd December, 2015

Liddah Chaka Chufa
Maseno University
Private Bag
MASENO.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on *"Assessment of vulnerabilities to drought as an indicator of climate change and adaptation options in pastoral production systems in Marsabit County, Kenya,"* I am pleased to inform you that you have been authorized to undertake research in **Marsabit County** for a period ending 1st **December, 2016.**

You are advised to report to the **County Commissioner and the County Director of Education, Marsabit 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.

DR. S. K. LANGAT, OGW
FOR: DIRECTOR GENERAL/CEO

Copy to:

The County Commissioner
Marsabit County.

The County Director of Education
Marsabit County.

APPENDIX III: PERMIT