USE OF SEASONAL CLIMATE FORECAST AND DROUGHT EFFECTS ON LIVESTOCK ASSETS IN BARINGO COUNTY, KENYA

RICHARD OCHIENG'

A Thesis Submitted to the Graduate School in Partial Fulfilment for the Requirements of the Award of the Doctor of Philosophy in Geography of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for an award of a degree in any other university to my knowledge

Signature…………………………………… **Date…………………………………**

Richard Ochieng'

ND13/0452/14

Recommendation

This thesis has been submitted for examination with our approval as the University supervisors

Signature……………………………………… **Date……………………………..…**

Dr. Charles W. Recha

Department of Geography, Egerton University

Signature……………………………………… **Date……………………………..…**

Prof. Bockline Omedo Bebe

Department of Animal Sciences, Egerton University

DEDICATION

I dedicate this work to **Gwara** and **Sai Baba** for the wonderful teachings of love, forgiveness, charity, contentment, inner peace and devotion to God

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ABSTRACT

Increased frequency, severity and duration of drought events in arid and semi-arid regions (ASALs) of Kenyan increase scarcity in water and pastures that support livestock assets. This destabilizes the livelihood base dependent on livestock assets. Use of seasonal climate forecasts (SCFs) can provide early warning of the drought events and inform actions to reduce vulnerability of pastoral households to drought effects. This study assessed trends and severity of drought events, their effects on livestock assets, effectiveness and usefulness of SCF in predicting drought events, and identified enabling conditions for better use of SCF. The study was in the ASALs of Baringo County in Lower Midland 5 (LM5) and Inner Lowland 6 (IL6) Agro-ecological zones. Data was from Meteorological Services, household survey, Key Informant interviews, and secondary sources. Computation of drought indices determined trends and severity of droughts. Means comparisons and Chi square determined drought effects on livestock assets and enabling conditions for use of SCF. Sensitivity analysis and correlation tests determined effectiveness and usefulness of SCF. Results showed a declining trend in rainfall between 1970 and 2008 with marked peak periods and extreme low rainfall corresponding to extreme climatic events. Drought re-occurrences were within shorter intervals and were characterised by trekking livestock, loss of livestock assets and decline in market value of stock. These observations corroborated with perceptions of pastoralists that livestock asset loss increases, productivity declines and stock market value declines during droughts. Annual rainfall correlated negatively ($r = -0.6879$, $p<0.05$) with drought events. Relayed SCF was 85.71% and 80.00% of the times effective in predicting March-April-May (MAM) and October-November-December (OND) seasons, respectively. The SCF was 75.00% and 57.14% of the times useful in prediction of MAM and OND seasons, respectively. In order of importance, the media, integration of traditional climate information and extension services were most effective enabling conditions for disseminating SCFs. Most important hindrances to use of SCFs were insecurity, conflicts, illiteracy, and lack of access to SCFs information. The study concluded that these ASALs would continue to experience decreasing trends in total annual rainfall, re-current droughts and even become drier over time. The drought events negatively affect livestock asset and different livestock species respond differently to rainfall variability and drought events. The seasonal climate forecasts are effective in predicting drought events and therefore useful tool in decision-making.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAME: Active Adult Male Equivalent

ACTED: Agence d'Aide à la Coopération Technique Et au Développement (Formerly Agency for Technical Cooperation and Development)

AEZs: Agro-Ecological Zones

ALRMP: Arid Lands Resource Management Project

ARIMA: Autoregressive Integrated Moving Average

ASAL: Arid and Semi-Arid Land

CARE: Christian Action Research and Education

DFID: Department for International Development

DMI: Drought Management Initiative

ECMWF: European Centre for Medium-Range Weather Forecasts

EWS: Early Warning Signs

ENSO: El Niño Southern Oscillation

FAO: Food and Agriculture Organization of the United Nations

FEWS-NET: Famine Early Warning Systems Network

GDEWF: Global Drought Early Warning Monitoring Framework

GDEWS: Global Drought Early Warning System

GFDRR Global Facility for Disaster Reduction and Recovery

GLOWASIS: Global Water Scarcity Information Service

ICDC: African Climate and Development Initiative

IDMP: Integrated Drought Management Program

IPAR: Institute of Policy Analysis and Research

IL6: Inner Lowland 6

IOD: Indian Ocean Dipole

IPCC: Intergovernmental Panel on Climate Change

ITCZ: Inter-Tropical Convergence Zone

KIRRA: Kenya Inter-Agency Rapid Assessment

KMS: Kenya Meteorological Services

LEWS: Livestock Early Warning Systems

LINKS: Livestock Information Network and Knowledge System

LM5: Lower Midland 5

MAM: March-April-May Rainfall (Long rains)

NACOSTI: The National Commission for Science, Technology and Innovation

NCCRS: National Climate Change Response Strategy

NCEA: Netherlands Commission for Environmental Assessment

NCEP: National Centre for Environmental Prediction

NDVI: Normalized Difference Vegetation Index

NDMA: National Drought Management Authority

NOAA: National Oceanic and Atmospheric Administration

OND: October-November-December Rainfall (Short rains)

PDSI: Palmer Drought Severity Index

RCOFs: Regional Climate Outlook Forums

RoK: Republic of Kenya

SA (t): Time series Standard Anomalies

SLAF: Sustainable Livelihood Approach Framework

SPI: Standardized Precipitation Index

SPSS: Statistical Package for Social Science

SSA: Sub-Saharan Africa

SSTs: Sea Surface Temperatures

SWSI: Surface Water Supply Index

TLU: Tropical Livestock Unit

UNCCD: United Nations Convention to Combat Desertification

UNDP: United Nations Development Programme

UNEP: United Nations Environment Programme

UNISDR: United Nations International Strategy for Disaster Reduction

WMO: World Meteorological Organization

CHAPTER ONE
INTRODUCTION

1.1 Background information

Drought is part of climate variability that can vary intra-annually, inter-annually, decadal or over century timescale (Nicholson, 2000). The variability associated with drought events can explain causes of droughts in Africa. Dutra *et al.* (2013) explained that drought in the horn of Africa results from rainfall variability in both October – December (OND) and March – May (MAM) seasons. In addition, rainfall variability can be associated with El Niño Southern Oscillation (ENSO), Inter-Tropical Convergence Zone (ITCZ), topography, urbanization and global warming. In addition, human induced factors such as climate change, environmental pollution and land-atmospheric interactions can also influence drought events as observed in the studies of Dai (2011; 2013), Hwang *et al.* (2013) and Lebel *et al.* (2009). Across Africa, the major factors influencing rainfall variability are ENSO, Sea Surface Temperatures (SST) and land-atmospheric interactions. The ENSO, SST and land-atmospheric interactions alters the atmospheric dynamics and circulation patterns (Nicholson, 2000; Masih *et al.*, 2014).

In the Southern Africa zone, a negative correlation with warm ENSO is more likely because occurrence of drought events takes place during the warm phase of ENSO and most drought events corresponding with El Niño years when the risk of drought increases by 120% in El Niño years (Rouault & Richard, 2005; Stige *et al.* (2006). Studies show a reduction in African food production when global changes shift more towards El Niño conditions (Stige *et al.*, 2006). In contrast, other studies have indicated that there are instances when droughts do not occur during the El Niño years because El Niño is not the only predictor of drought (Richard *et al.*, 2001; Manatsa *et al.*, 2008). Drought events in the Eastern African region are experienced during La Niña (The cold cycle of ENSO) (Dutra *et al.*, 2013; Hastenrath *et al.*, 2007; Lott *et al.*, 2013). Dutra *et al.* (2013) and Lott, *et al.* (2013) attributed droughts of 2010-2011 in Africa to La Niña phenomenon while Funk *et al.* (2008) and Williams & Funk (2011) associated dry conditions arising from decline in precipitation along the Eastern Africa zone with the warming of the central Indian Ocean induced by greenhouse gases and aerosol emissions in late 20th century. The warming influences reduction in seasonal rainfall, resulting in drought occurrence along the Eastern African zone.

Drought events in Kenya have increased in frequency, severity and duration and associated impacts are more severe on pastoral livelihoods in Arid and Semi-arid Lands (ASALs). Vulnerability to drought impacts is associated with low adaptive capacities (Eriyagama *et al.*, 2009; Kipterer & Ndegwa, 2014) because pastoral communities experience high poverty levels and are dependent on natural resources and rain fed agriculture. When drought events reoccur with high frequency and severity, livelihoods dependent on livestock assets are destabilised (Wang *et al.*, 2015). This results from significant changes in precipitation patterns that expose livestock to scarcity of water and feed resources and sometimes to disease outbreaks. This is a development concern that is attracting increasing attention for adaptation options that can stabilise livelihoods of pastoral households (Wilhite, 2005; Wilhite, 1990).

The frequency of drought occurrences can be associated with precipitation given that rainfall received and the observed drought events correlate negatively. If the consecutive rainless days' span more than one season, the magnitude of drought will depend on the season with the majority of consecutive rainless days (Wang *et al.*, 2015). Because the amount of rainfall received and drought occurrence are associated, drought events have influence on livelihood assets that are sensitive to rainfall.

Droughts are recurrent events which on average, are catastrophic every 10 years (Orindi *et al.*, 2007; Netherlands Commission for Environmental Assessment [NCEA, 2015]) but are almost on annual basis in the ASALs of Kenya (United Nations Development Programme [UNDP, 2016]), resulting in cyclic years of destabilised livelihoods. Forecasting seasonal climate could be a strategy to build necessary adaptive capacity through effective dissemination of the information to the vulnerable groups (Klopper *et al.*, 2006; Patt *et al.*, 2005). Climate information and predictions are useful in making informed management options relating to planting, fertilizer, pesticide applications, irrigating, harvesting and pastoral livestock production (Gadgil *et al.*, 2002; Hansen, 2002; Hansen & Indeje, 2004). Klopper *et al.* (2006) have suggested that combining seasonal climate forecasts with a range of other tools and methods can enhance decision-making and improve overall risk management. The widely used response adaptation strategies include: planting short duration crops and different crop varieties; reliance on remittances from relatives working in towns; involvement in seasonal jobs; offering labour in return of food; engaging in non-farm economic activities; shift from crop to livestock farming; and selling off livestock during dry seasons (AMCEN, 2011; IPCC, 2014; Smit *et al.*, 2000).

Current approaches used for producing seasonal climate forecasts include use of physically based global climate models, regional climate models and empirically based statistical models (Coelho & Costa, 2010; Kumar *et al.*, 2012; Giannini *et al.*, 2008). These can be options for building adaptive capacity if they are packaged to meet the ultimate needs of the end users (Saha, *et al.*, 2006) to inform decision making (Lemos & Morehouse, 2005; Ingram *et al.*, 2008). The current seasonal climate forecasts involve a multi-disciplinary focus aimed at producing integrated assessments and participatory models of science – policy interactions, with the potential of increasing usability and solving end-users' problems. However, Lemos & Rood (2010) highlights sources of climate projections uncertainties that vary across scale and systems including product of research process that makes decision-making process more complex, institutional mismatch and constraints, competing issues, lack of resources and faulty communications. These are potential barriers to effective use of seasonal climate forecast even if disseminated and therefore require resolving. They are barriers because of uncertainty about forecast information accuracy, timing of release, data format and mode of communication and the relative social and economic vulnerability of the targeted households (Lemos *et al.*, 2002).

Studies have established constraints limiting use of forecasts among pastoral communities Klopper, *et al.*, 2006; Lemos *et al.*, 2002; Lemos & Rood, 2010; McCrea *et al.*, 2005). One is credibility, which results from the failure of forecasts to communicate accurate information especially when in deterministic, rather than probabilistic form. Probabilistic statements are preferred and attractive to users because users they can easily translate them into decisions (Klopper, *et al.*, 2006; Lemos *et al.*, 2002; Lemos & Rood, 2010; McCrea *et al.*, 2005). Two is illegitimacy arising where perception is that assessment is recommending behavioural changes with potential disproportionate benefits to some actors. Pastoral communities may be unable to benefit from forecasts if they do not understand the message easily. For instance, when the information covers a wide geographical area such as an entire continent, region or country but where the local implications of that information remain unclear. Three is constraints to downscaling - rainfall and drought patterns may be very heterogeneous over a small physical area and it may be impossible to downscale a forecast's temporal dimension. Cognition is an issue as well– which occur when users do not understand a forecast and therefore use it incorrectly or not at all. Fifth is procedure – arising when forecasts take long to reach the end users due to various standard operating procedures. Sixth is choice – related to forecasts not containing enough new information to alter specific decisions. Pastoral farmers will always make decisions based on cost effectiveness analysis (meeting predetermined objectives at the least cost) rather than cost-benefit analysis (choosing the objectives and the means to maximize net gains) (Patt & Gwata, 2002; Thompson & Rayner, 1998; Ziervogel, 2001).

Enhancing access and use of seasonal climate forecasts among pastoral households in the ASAL areas such as Baringo County would be beneficial to stabilising livestock asset based livelihoods. The Kenya Meteorological services release forecasts while the National Drought Management Authority disseminates early warnings. Most stakeholders do not understand well the degree of usage and barriers to seasonal climate forecasts and early warnings, a probable explanation to continued vulnerability of pastoralists to drought. The traditional pastoral response strategy to drought is herd mobility in search of pasture and water but this strategy increases pressure on the grazing pastures and watering points. In addition, it exposes livestock to risks of disease outbreak, loss of livestock assets through starvation, loss of body condition and loss of market value and even death (Birhanu *et al.*, 2015; Kassahun *et al.*, 2008). Droughts are associated with price variability of livestock and livestock products in ASALs (Birhanu *et al.*, 2015), therefore livelihood options are eroded during droughts because of dependency on rain-fed agriculture and livestock assets.

1.2 Statement of the Problem

Severe extreme drought events in the ASALs adversely destabilise livelihoods of pastoral households through exposure of livestock assets to scarcity of pasture and water. Herd mobility deployed as an adaptation response worsens the situation, further exposing livestock to risks of disease outbreaks, mortalities and loss of market value. Implementing planned adaptation is necessary to secure livestock assets from effects of drought. The government, NGO and private sectors have been implementing several adaptation interventions including establishing drought management institutions, targeted drought response policy, climate information provision, increased budgetary allocation to drought interventions and empowerment of vulnerable households to build adaptive capacity to droughts. However, the ASAL communities, especially those in Baringo, remain vulnerable to impacts of drought events. Continued vulnerability is likely resulting from inadequate use of seasonal climate forecast to prepare for the envisaged drought. The vulnerability of the pastoral communities to drought is often location specific, which needs establishing both biophysical and socio-economic vulnerability of the households. This study envisages that providing localised information on drought trends, use of seasonal climate forecasts and early warning indicators present option for securing livelihood assets of the pastoral community during drought events.

1.3 Objectives of the Study

1.3.1 Broad Objective of the Study

The broad objective of this study was to support building of adaptive capacity among Baringo County pastoral communities to droughts through better access and utilization of seasonal climate forecasts.

1.3.2 Specific Objectives of the Study

The following specific objectives guided the study:

i. To characterise trends and severity of drought events during 1970 – 2013 period in LM5 and IL6 agro-ecological zones of Baringo County
ii. To determine perceived and observed effects of drought events on livestock assets in Baringo County
iii. To quantify the effectiveness and usefulness of seasonal climate forecast in predicting the observed drought events in Baringo County
iv. To identify enabling conditions for utilization of seasonal climate forecast by pastoral households in Baringo County

1.4 Research Questions

i. What have been the trends and severity of drought events during 1970 – 2013 period in LM5 and IL6 agro-ecological zones of Baringo County?

ii. What are the perceived and observed effects of drought events on livestock assets in Baringo County?
iii. To what degree are the seasonal climate forecasts effective and useful in predicting the observed drought events in Baringo County?
iv. Are there enabling conditions for utilization of seasonal climate forecast in pastoral community areas of Baringo County?

1.5 Justification of the Study

Drought events are a threat to pastoralism and its effects vary over time and space, calling for more case-focused studies. It is therefore important to characterize and assess potential effects of such events at various scales in order to access location-specific data to guide appropriate decision making, reduce vulnerability and secure the livelihoods of the pastoral community (Chipanshi *et al.*, 2003). Morton (2007) considers location-specific factors and livelihood systems in different ecosystems in establishing impacts on pastoral systems. The study of drought brings important theoretical contributions since it allows a more detailed knowledge of drought events and of its role in the characterization of climate of a given region. Such information is essential to informing decisions aimed at addressing the consequences of drought events (Washington *et al.*, 2006).

The present study sought to identify opportunities for implementation of seasonal climate forecasts as an adaptation strategy in Arid and Semi-Arid lands. It carried out drought analysis and generated detailed information on household vulnerability to drought episodes in the Arid and Semi-Arid Baringo County. The information will help improve the adaptive capacity of the pastoralists in similar environmental conditions. The present study is anchored on past studies that recommended further research on the use of seasonal climate forecasting by pastoral communities, with keen focus on the pastoralists' ability to access, trust and respond to the forecasts (Morton, 2007; O'Brien & Vogel, 2003; Thomson, 2003). The study sought to strengthen the resilience of ASAL communities to drought and other climate related disasters, an objective of the ASAL policy.

Other policy options the study reinforces include Vision 2030 that seeks to attain a secure, just and prosperous Northern Kenya and other arid lands where people achieve their full potential and enjoy a high quality of life (RoK, 2007; RoK, 2011). The Constitution of Kenya 2010 which provides an affirmative action to redress historical marginalization of the ASALs and provides a strong grounding for the ASAL Policy of 2012 (Ochieng', 2013; RoK, 2010a; RoK, 2012b). National Land Policy (2009) aims at laying a strong foundation for sustainable development of the ASALs (RoK, 2009; RoK, 2010a; RoK, 2012a; Ochieng', 2013). The National Disaster Management Policy (2012) set to achieve the following objectives: identify disaster sub-regions, evolve strategies for the sub-regions, integrate a national strategic plan, harmonise Disaster Management for all disasters, provides for coordination of all Disaster Management-related activities, and promote continuous stakeholder consultations with relevant line Ministries, to enhance co-ordination of interventions (RoK, 2012b). The Water Act (2002) aims at achieving the following: determine the requirements of the reserve for each water resource; classify resources; identify areas, which should be designated protected areas and ground water conservation areas (RoK, 2002).

The National Policy for the Sustainable Development of Northern Kenya and Other Arid Lands focuses on issues which are distinctive of ASALs and which required specific responses. The policy is in line with international agreements and treaties e.g. the Desertification Treaty (RoK, 2012a). The National Environment Policy (2012) goal is to provide a better quality of life for current generation without compromising the quality of life of the future generations through sustainable management of the environment and natural resources (RoK, 2012c). Kenya National Climate Change Action Plan (2013-2017) aims at operationalisation of Kenya's strategy and international obligation of ensuring a climate resilient and low carbon nation (National Climate Change Action Plan [NCCAP], 2012). The Climate Change Act of 2016 domesticates all national and international laws, regulations and treaties regarding climate change in Kenya. The Act provides framework for administering climate change fund, sets the targets for regulation of greenhouse gas emissions (RoK, 2016). The National Climate Change Response Strategy (NCCRS) (2010) target to address the challenges associated with climate variability and change (RoK, 2010c). These policy options aim at laying a strong foundation for sustainable development of the ASALs. RoK (2011) and IPAR (2002) base successful achievement of transforming the ASALs on the attention given to the distinct challenges facing the region and a shift from focusing at the ASALS as net consumers of the national wealth.

It is worth noting that through understanding the trends of drought, its effects on livestock assets and enhanced utilisation of seasonal climate forecast, the present study aims at achieving the objectives of sustainable livelihood (Scoones, 1998). This is possible through sustainable use of natural resources, enhanced income for the pastoral communities, improved wellbeing of the pastoralists and reduced vulnerability to effects of drought. By effectively understanding the changing environment, available options and adapting to climate variability and drought events, the pastoralists are able to meet their household food demand.

1.6 Scope and Limitation of the Study

This study focused on rainfall events, being the most significant climate elements that influence livestock production. The study area was in extreme arid and semi-arid zones being the driest regions of Baringo County where pastoral livelihoods dominate. Data on rainfall and seasonal climate forecast were dependent on their availability and accessibility. Rainfall data obtained was for the period 1970-2008 at Perkerra station in LM5 zone and for period 1974-2013 at Nginyang in IL6 zone.

The seasonal climate forecasts data were preferred for being of value to pastoral community in allowing ample time to prepare response to predicted scenarios. Accessed early warnings and climate forecasts data were for the period 2005 – 2015. Data on drought effects on livestock performance obtained from government agencies had gaps. Data on milk production for period January to December 2009 – 2015; livestock owned for period January-December 2015; livestock deaths for period January-December 2015, livestock prices for period January-December 2013-2015. The household survey data was a five-year recall of effects of drought on livestock.

1.7 Operational Definition of Terms and Concepts

Adaptation: Refers to adjustments in livelihood systems or practices in response to extreme rainfall events or drought. It is associated with planned action, either anticipating threats or averting impacts of drought events. The adjustments help moderate the harm associated with drought events or exploit beneficial opportunities to increase resilience.

Arid and semi-arid lands (ASALs): Refers to regions where land is dry and deficient in moisture due to insufficient precipitation and high rate of evaporation that is over and above moisture supply. The ASAL regions have more than 30% of their area with an evapo-transpiration of more than twice the annual rainfall.

Pastoralism: Describes a livelihood based primarily but not exclusively upon the production, sale and consumption of livestock and livestock products such as meat, milk and other dairy products and hides. In involves extensive production of livestock that takes advantage of the instability of rangeland environments, commonly practiced in arid and semi-arid lands. Main defining features include livestock mobility in times of drought in search of pasture and water and communal management of natural resources.

Drought: the present study focussed on meteorological drought that is based on the degree of dryness and duration of the dry period. The definition considers spatial variations since the atmospheric conditions resulting from precipitation deficiencies have spatial variability. The study used World Bank (2013) definition to classify drought i.e. Anomaly lower than -0.9 = catastrophic drought, Anomaly between -0.9 and -0.6 = severe drought, Anomaly above -0.6 = not severe.

Livestock off-take: this is the proportion of animals sold or consumed in a year.

Pastoral livestock assets: these are benefits or values derived from livestock production and convertible into cash. For the purpose of this study, livestock assets refer to Total Livestock Unit, stock value and livestock off-take.

Seasonal climate forecasts: probabilistic information usually issued in probable categories of normal, below normal, near normal and above normal for a specified season and geographic location by the Kenya Meteorological Services (Recha, 2013). The term seasonal climate forecast is used in meteorology and climatology to refer to estimates of seasonal-mean statistics of weather, typically up to three months ahead of the season in question. It provides information on how likely it is that the coming season (MAM or OND) will be wetter, drier, warmer or colder than normal (Weisheimer & Palmer, 2014).

Total Livestock Unit (TLU): Refers to the equivalence between different species of livestock. A TLU is 250-kilogram live weight of any domestic herbivore.

Vulnerability: Refers to the inability to withstand the effects of drought events in the study area. The degree to experience harm due to exposure to drought adversely affecting livestock production.

Drought early warning stages:

Normal:

Environmental, Livestock and pastoral welfare indicators show usual fluctuations and remain in the expected seasonal range.

Alert:

Environmental indicators show unusual fluctuations outside expected seasonal ranges. This occurs within the entire district, or within localized regions; or Asset levels of households are still too low to provide an adequate subsistence level and vulnerability to food insecurity is still high.

Alarm:

Environmental and livestock/agricultural indicators fluctuate outside expected seasonal ranges, affecting the local economy. This condition occurs in most parts of the district, and directly and indirectly threatens food security of pastoralists and/or agro-pastoralists.

Emergency:

All indicators are fluctuating outside normal ranges. This situation affects the asset status and purchasing power of the population to an extent that welfare levels have been seriously worsened resulting in famine threat.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter reviews previous works and trends related to the research problem as characterised by rainfall variability, trends and risks of drought events, effects of drought events on livestock assets, utilization of seasonal climate forecasts for securing livestock assets and enabling institutions for better utilization of seasonal climate forecasts. The chapter identifies the current gaps in the literature and presents the conceptual framework that guided the study design and implementation.

2.2 Climate Variability

Studies have established that among all the climatic elements, rainfall display the highest spatio-temporal variability in East Africa influencing both the onset and cessation of rainfall in the region (Mugo *et al.*, 2016; Kisaka *et al.*, 2015; Omondi *et al.*, 2013; Ogallo, 1988). The East Africa region experiences two rainy seasons which include the March to May (MAM), referred as the long rains and the October to December (OND) known as the short rains (Mugo *et al.*, 2016). Several studies have shown interest in understanding seasonal rainfall patterns, taking into consideration rainfall amounts, rainy days, lengths of growing seasons and dry spell frequencies (Ngetich *et al.*, 2014; Mugalavai *et al.*, 2008; Kisaka *et al.*, 2015). Mugo *et al.*, (2016) indicates that the spatio-temporal variability in terms of distribution, duration, intensity and periods of dry spell has been noticed across the East Africa region. This has often affected agricultural production, pastoral activities and food security. High intra-seasonal variability and variations in onset and cessation dates have been observed in MAM rainfall seasons (Kisaka *et al.*, 2015; Omondi *et al.*, 2013; McHugh, 2004).

Rainfall variability in Kenya has been attributed to complex topography, existence of large inland lakes, the Indian Ocean, urbanization, Inter-Tropical Convergence Zone (ITCZ), El Niño Southern Oscillation (ENSO) and global warming other factors (Mugo, *et al.*, 2016; Kisaka *et al.*, 2015; Omondi *et al.*, 2013; Matondo, 2010). In recent past, Kenya experienced extreme drought events characterized by failure in seasonal rains (Koumare, 2014; Ongoma *et al.*, 2015). William & Funk (2011) associated the drying trend with rapid warming of the Indian Ocean seas surface temperatures (SST), resulting in subsidence anomaly and drying over East Africa. Lyon

& DeWitt (2012) linked the decline in the East African long rains with a shift to warmer SSTs over the Western Tropical Pacific and cooler SSTs over the Central and Eastern Tropical Pacific.

Understanding the parameters such amount of rain per rainy day and mean duration between successive rainy season helps in understanding the long-term rainfall variability of any given area, an aspect that is inhibited by lack of adequate meteorological stations at local level affecting the quality of meteorological data (Akponikpe *et al.*, 2008; Kisaka *et al.*, 2015). Utilisation of GIS spatial-interpolation techniques such as inverse distance weighted, Spline and Kriging interpolation and use of imputation are some of the approaches employed in meteorological data reconstruction to address the problem of inadequate, inconsistent, unrecorded or missing data (Kisaka *et al.*, 2015; Enders, 2010).

Attention of scientific community has recently shifted to analysis of climate information for periods between 5-10 years for interventions and planning purposes (Omondi *et al.*, 2013; Knutson & Tuleya, 2004). Studies considers knowledge on decadal climate variability the new dimension in climate science and rainfall variability (Knutson & Tuleya, 2004; Hibbard *et al.*, 2007; Meehl *et al.*, 2009; Omondi *et al.*, 2013). Studies indicate that there is a link between decadal drought frequencies in the Sahel to sea surface temperatures (Hulme, 1992; Lamb & Peppler, 1992; Zhang & Delworth, 2006). There is adequate evidence of decadal climate variability in the observed system over the East Africa region (Nicholson, 2000; Bowden *et al.*, 2005; Omondi *et al.*, 2012; Nzioka *et al.*, 2008).

There is evidence that climate has been changing, posing a lot of stress in rainfall variability and drought management, an environmental hazard that threaten human existence and livelihood in Arid and Semi-Arid lands (Chaponniere & Smokhtin, 2006). Drought is cyclic environmental hazard with widespread impacts on livestock in Africa subjecting pastoral communities to livestock losses (Masih *et al.* 2014). EM-DAT (2014) indicated that the world experienced 642 severe droughts between the period 1900-2013 resulting into economic damages amounting to USD 135 billion. According to Intergovernmental Panel on Climate Change (IPCC, 2012), there is medium confidence that some regions of the world have experienced more intense and longer droughts, in particular in Southern Europe and West Africa. In some regions droughts, have become less frequent, less intense or shorter e.g. central North America and North-Western Australia. There is confidence that droughts will intensify in the 21st

Century in some regions and areas due to reduced precipitation and/or increased evaporation. Ziervogel *et al.* (2006) indicates that food security revolves around economic, social, political, environmental and climatological factors and therefore solution requires an integrated approach.

There is need for a deeper understanding of climate variability, drought events and associated livelihoods to help reduce vulnerability. Studies have shown that a number of factors including greenhouse gases in the past influenced drought events and the trend expected to continue based on the actions of human race on the earth surface (Ziervogel *et al.*, 2006). Appropriate policy formulation and implementation alongside community empowerment is a right pathway towards addressing the problems associated with drought. Most developing countries lack appropriate technologies, capacity and resources that can precisely monitor and predict drought events (Tadesse *et al.*, 2008; Vogel *et al.*, 2010). Livestock production in Arid and Semi-Arid lands is one of the most sensitive sectors to the risks of drought events in developing countries (Masih *et al.*, 2014). The growing demands for water and pasture in ASALs have worsened the drought impacts in the world (Masih *et al.*, 2014). The ASALs receive limited amount and unreliable rainfall distribution, making the areas sensitive and highly vulnerable to drought. Increasing population pressures in ASALs coupled with declining and reduced pasture impacts negatively on livestock production (Ziervogel *et al.*, 2006).

Efforts to respond to drought should focus on the current vulnerability, present and future risks and appropriate responses to reduce vulnerability (Kaimba *et al.*, 2011; Ziervogel *et al.*, 2006). However, there have been considerable efforts in monitoring, forecasting and mitigation as the damages have continued to worsen (Masih *et al.*, 2014; Vogel *et al.*, 2010; United Nations International Strategy for Disaster Reduction [UNISDR], 2010). Based on previous studies on drought events and associated effects, there is urgent need to focus on early warning and climate forecasting, alongside long-term planning and capacity building (Calow *et al.*, 2010; Clarke *et al.*, 2012; Falkenmark & Rockström, 2008; GFDRR, 2011; Logar & van den Bergh, 2013; Mishra & Singh, 2010; Tadesse *et al.*, 2008; Vicente-Serrano *et al.*, 2012). In-depth understanding of past drought events can improve drought mitigation and preparedness and therefore reduce vulnerability (Masih *et al.*, 2014; Vogel *et al.*, 2010; Vicente-Serrano *et al.*, 2012), an objective that the present study sought to achieve. Such studies provide a solid foundation for understanding the recurrent nature of drought and its relationship with climate change (Mishra & Singh, 2010).

Drought is determined based on a deviation from normal rainfall for a particularly area for a given period. Despite of several past studies, diagnoses of the reasons behind declining long-rains precipitation have been elusive because of complicated factors that control inter-annual variability of long-rains precipitation totals (Ogallo, 1988; Camberlin & Philippon, 2002; Pohl & Camberlin, 2006). More so, there is inadequate study in Baringo County regarding use of seasonal climate forecast as an adaptation strategy (Kaimba *et al.*, 2011; Kipterer & Ndegwa, 2014). Knowledge of drivers of climate variability is important in enhancing adaptation tools such as seasonal climate forecasts.

2.3 Drought Assessment

Drought risks and vulnerability have attracted assessment of drought impacts on livestock based livelihoods to reduce the vulnerability (Chipanshi *et al.*, 2003, Wilhelmi *et al.*, 2002; Brunett *et al.*, 2002; Svoboda *et al.*, 2002; Homewood & Lewis, 1987). These have involved drought monitoring and early warning (Svoboda *et al.,* 2002), drought policy and mitigation strategies (Brown, *et al.*, 2006). In detailed assessments, analysis of drought occurrences and effects use meteorological variables. These include rainfall, temperature, soil water holding capacity and other water supply indicators. The variables are useful in generating drought indices because they are considered a key element in defining a drought and deciding on the techniques for the analysis. Drought indices describe the severity of drought as compared to the long-term average on normal condition (Hayes 2003; Keyantash & Dracup 2002). Despite efforts to strengthen the adaptive capacity, livelihoods in the Arid and Semi-Arid Lands (ASALs) remains vulnerable to drought events associated with climate change and variability. Davies *et al.* (2009) indicates that loss of assets and low adaptive capacity of the poor communities exacerbates community vulnerability to environmental hazards.

Drought studies use different methods to analyse drought events. Fleig *et al.* (2006) conducted studies using observed data useful in examining geographical differences in the statistical nature of droughts but are constrained by limited observation points hence need to use different or incorporated approaches. Sheffield & Wood (2007) used monthly drought based on simulated soil moisture data to identify the locations most prone to short, medium and long-term droughts and to examine severe past drought events on a regional basis. Dai *et al.* (2004) developed a global monthly data of Palmer Drought Severity Index while Dettinger & Diaz (2000) used monthly stream-flow series to characterize and map geographic differences in the seasonality and annual variability of stream-flow, which influences drought events globally. Lloyd-Hughes & Saunders (2002) developed grid-based climatology for Europe, which provides the time series of drought strength, the number, the mean duration of droughts of a given intensity and the trend in drought incidence based on Standardized Precipitation Index. A number of indices provide crucial means of monitoring drought. They measure how much precipitation for a given period has deviated from historically established norms. The most commonly used indices in drought analysis include:

i. Percent of normal: The index is computed by dividing the actual precipitation by the normal precipitation typically considered to be a 30 – year mean and multiplying by 100 ($I = (P_0 \div P_{30}) \times 100$; Values of the index less than 100 means drought conditions exist).
ii. Deciles: The distribution of the time series of the cumulated precipitation for a given period divided into intervals each corresponding to 10% of the total distribution (Deciles). Gibbs & Maher (1967), grouped deciles into 5 classes as shown in table 2.1.

Table 2.1

Classes of events

Class	Percent	Period
Deciles 1-2	20% lower	Much below normal
Deciles 3-4	20% following	Below normal
Deciles 5-6	20% medium	Near normal
Deciles 7-8	20% following	Above normal
Deciles 9-10	20% more high	Much above normal

Source: Gibbs & Maher (1967:10)

The decile index is easy to compute but requires a long-time series of data that is not readily available in most African countries (Masih *et al.*, 2014; Gibbs & Maher, 1967).

iii. Palmer drought severity index (PDSI): Developed by Palmer (1965) and Palmer (1968) and based on the supply and demand concept of the water balance equation. It measures the departure of the moisture supply for normal condition at a specific location based on precipitation and temperature data on the local available water content of the soil and other meteorological parameters. The Palmer index varies between -6.0 and +6.0 as shown in table 2.2. The PDSI identifies abnormality of agricultural droughts and historical aspects of prevailing situations. The method depends on soil moisture data that possess challenge to analyse over a wide geo-spatial scale (Palmer, 1965; Palmer, 1968; Masih *et al.*, 2014).

Table 2.2

Palmer index classification

PDSI	Class
4.0 or more	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to -0.49	Mild drought
-2.0 to -2.99	Moderate drought
-3.0 to -3.99	Severe drought
-4.0 or less	Extreme drought

Source: Palmer (1965: 2)

iv. Surface water supply index (SWSI): Developed by Shafer & Dezman (1982) to complement Palmer index and designed for large topographical variations across a region and accounts for snow accumulation and subsequent runoff. The index use monthly data collected and summed for all the precipitation stations, reservoirs and snowpack/stream-flow measuring stations over the basin. The index analysis involves normalization of summed component using a long-term mean. The index is centred on zero and has a range between -4.2 and +4.2

v. Normalized difference vegetation index (NDVI): This index can monitor rangeland conditions, desertification and changes in the land use systems. NDVI and forage conditions are important factors in forecasting droughts and livestock mortality. NDVI measures vegetation cover and productivity by computing the proportion of absorbed radiation from the photosynthesis process. This ratio of visible and near infrared wavebands ranges between negative one (-1) and positive one (+1) with zero or less indicating non-vegetation cover. Values close to +1 indicate a high level of green vegetation cover or biomass while bare soil cover records lower NDVI values of between 0.1 to 0.2 (Wittemyer *et al.*, 2007; Tucker *et al.*, 2005).

vi. The Standardized anomalies: Estimation of standardized anomalies is carried out using the following formula:

$SA(t) = \{SP(t) - \mu\} \div \{\sigma\}$

Where:

SA (t) = time-series of standardized anomalies

SP (t) = cumulative precipitation during the season

μ = represents mean

σ = standard deviation

Interpretation of Standard Anomalies uses World Bank (2013) definition as follows:

Anomaly lower than -0.9	=	Catastrophic drought
Anomaly between -0.9 and -0.6	=	Severe drought
Anomaly above -0.6	=	Not severe

The standardised anomalies method is mostly preferred because it is simple to use and only requires precipitation data for computation of the indices (Zargar *et al.*, 2011). The method monitors drought parameters such as drought onset, intensity and duration (Dai, 2011; Mishra & Sing, 2010; Smakhtin & Schipper, 2008). The present study used the standardized anomalies to identify and classify droughts. It further established the contribution of seasonal climate forecasts, an adaptation strategy, in strengthening the adaptive capacity of the pastoralists in the Arid and Semi-Arid Baringo County.

Studies that have investigated within-season dry spells and their impact on agricultural production include World Bank (2013), Recha *et al.* (2012) and Mzezewe *et al.* (2010). These studies established that occurrence of dry spells affect agricultural production. The present study identifies with these studies but went further to identify and classify drought in Arid and Semi-Arid Baringo County with a view of generating location-based information crucial in decision making regarding adaptation options to drought events.

2.4 Effects of Drought Events on Livestock Assets

Drought events pose serious threats to livestock production through increased temperatures, shifts in rainfall distribution and pasture productivity. The indirect impacts can result from reduced quality and availability of feed and fodder, emergence of livestock disease and greater competition for resources with other sectors. Greater effects of drought on livestock is on grazing systems of ASALs because of their dependence on climatic conditions, natural resource base and their limited adaptation opportunities as well as increasing land degradation and consequent reduced pasture yields (Aydinalp & Cresser, 2008; Kipterer & Ndegwa, 2014; Kaimba *et al.*, 2011; Hoffman & Vogel, 2008; Homewood & Lewis, 1987). Zamani *et al.* (2006) indicates that the ASALs of Africa experience recurring droughts that have significant effects on pastoral livestock production and livelihoods.

There is universal agreement that drought will affect the poorest members of societies more than the economically advanced (RoK, 2010b). This is because the economically advanced countries have the ability to adapt to the anomalies by their sheer wealth (RoK, 2010b). Studies indicate that the effects of climate change and drought will be spatially heterogeneous and greater among the poor agricultural households particularly in Sub-Saharan Africa (Brooks & Adger, 2005). There was need to carry out location-specific research focusing on the ASAL Baringo County to address the effects of drought and reduce vulnerability among the pastoral community.

Eriyagama *et al.* (2009) indicates that infrastructural development of any country determines the level of its preparedness to drought. From analysis by these authors, there has been little attempt, if any, to comprehensively describe and map various aspects and impacts of a drought as an individual disaster and global multi-faceted phenomenon. This existing knowledge gap need filling especially in ASALs where the socio-economic drought vulnerability is generally higher since the countries are largely agricultural economies. Long-term droughts coupled with high infrastructural and socio-economic vulnerability contribute to food shortage, malnutrition, disease, conflict and famine in Africa. It is important to map drought vulnerability at smaller administrative subdivisions within countries. This can help generate scientific knowledge base for operational drought tools such as drought monitoring and warning signs forming part of national drought preparedness plans (Eriyagama *et al.*, 2009). Hayes *et al.* (2011) in a study to analyse the Lincoln declaration on drought indices, established that there is an urgent need to improve drought monitoring and early warning systems in order to cope with the current and potentially changing the drought patterns. The study underscores the role played by early warning systems in addressing the vulnerability of pastoralists to drought.

Allamano *et al.* (2010) reveal that rainfall variability and drought has significantly affected the rural smallholder farmers and pastoral community who rely mostly on rainfall for agricultural production and sustenance of livelihoods. It has led to significant reduction in crop and livestock production affecting the outputs and forcing farmers to adopt new agricultural techniques fitting the altered conditions.

Location specific research is crucial in addressing specific needs of a society. RoK (2010c) indicates that such studies can help identify specific sectoral research needs and appropriate climate change and drought response strategies. National Climate Change Response Strategy (NCCRS) stresses the need for research in agricultural sector to develop superior drought-tolerant, fast maturing, disease and pest resistant crop varieties; this can include livestock breeds (RoK, 2010c). The level of superior varieties varies from place to place influenced by spatial variability.

Kenya is a drought prone country because of its sparse eco-climatic conditions. The country contains few high potential climate regions of annual rainfall average above 2000 mm with 80% of Kenya's land mass being arid and semi-arid prone to harsh weather conditions (Serigne, 2006; Kaimba *et al.*, 2011; Homewood & Lewis, 1987). Approximately 70% of Kenya's land mass is affected by drought and in turn negatively impacting upon the livelihoods of the ASAL community. The region from to time, experience false and/or late onset of rains, late or early cessation of rains and frequent fluctuations for rainfall received across the region (Lobell & Burke, 2010; Mugalavai *et al.* 2008).

Kenya's vulnerability to food insecurity is the highest among the majority of pastoralist in Arid and Semi-Arid lands raising the need for identification and implementation of appropriate and effective adaptation strategies to increase resilience (UNDP, 2016; UNDP, 2014). The ASALs have the lowest development indicators and highest incidence of poverty in Kenya calling for intense focus to salvage the ASAL communities (RoK, 2011). RoK (2011) attributes the tribulations of ASALs to past public policy choices pursued by colonial government who divided Kenya into two main regions: The high potential and low potential. The low potential regions comprising of the arid and semi – arid lands received very little attention from the past regimes because they were perceived as liability regions. Early settlers ignored the ASALs making it lag behind economically. According to Sessional Paper No. 10 of 1965 on African Socialism, the idea of past regime was to invest in regions that would yield the largest increase in net produce (RoK, 2011; RoK, 1965). This historical inertia gave advantage areas that were initially favoured to develop exponentially at the expense of low the ASALs. This notion guided the investment of government resources across the nation with social and physical infrastructure of the ASALs neglected (RoK, 2011; RoK, 1965).

The vulnerability of a particular community or livelihood system is a function of three main factors: exposure, sensitivity and adaptive capacity (Adger, 2003). The present study regarded droughts, effect on livestock and use of climate forecast as exposure, sensitivity and adaptive capacity respectively. It is worth noting that the effects of drought vary in space and time, calling for location based and temporal studies on the effects and appropriate response strategies to drought events.

Admassie & Adenew (2007), Deressa *et al.* (2008) and Allamano *et al.* (2010) reveal that rainfall variability has significantly affected crop farmers and pastoralists who rely mostly on rainfall for crops and livestock production respectively. Livestock farmers who do not own grazing land, female-headed households and households with low level of education who do not have assets are the most affected by drought (Lemos *et al.*, 2002). Studies indicate that droughts have affected Kenya in the past and will continue to negatively impact upon the nation (NCEA, 2015). More than 28 droughts have been recorded in Kenya within the last 100 years, sending signals to the risks that community that depend on rain-fed livelihoods area likely to face (Huho & Mugalavai, 2010; Huho *et al.*, 2011). Across sub-Saharan Africa, climate is highly variable and manifest in climate extremes such as droughts (IPCC, 2007a; IPCC, 2007b; IPCC, 2007c).

Rainfall, among other factors dictates land-use in Africa limiting livelihood options for the continent (Kori *et al.*, 2012).

According to IPCC (2007a) climate change and variability has led to significant reduction in land under crops and pasture affecting crop and livestock productivity aggravating cases of food insecurity. The pastoral sector is the main source of food for the ASAL communities in Sub-Saharan Africa, an activity dictated upon by environmental factors. It is mainly depended on rain fed natural pasture, exposing pastoral livestock production to high seasonal rainfall variability and drought (Alvaro *et al.*, 2009: Ogen, 2007). Drought events influence livestock production in terms of growth, milk production, reproduction, quantity and quality of pasture, forage, severity and distribution of livestock disease and parasites (Niggol & Mendelsohn, 2008; Babagana & Leyland, 2008).

According to Yesuf *et al.* (2008), Admassie & Adenew (2007) and Zoellick (2009), drought events in ASALs affects the production and productivity by increasing pests and diseases, aggravating lack of land under pasture and water sources. This finding is in concurrence with Morand *et al.* (2013) who found out that climate change and drought influence distribution of parasites and diseases. Lack of access and use of seasonal climate forecasts, poor health, undernourished population, high population pressure and lack of institutional capacity to adaptation exacerbate the effects. The total seasonal rainfall amount or intra-seasonal rainfall distribution determine the impact of drought events on livestock production across ASALs (Bewket, 2009).

In a study carried out in Middle Belt of Nigeria, Ayanlade *et al.* (2009) indicates that annual rainfall variability has considerable effects on crop and livestock produce, negatively affecting yields. Studies have rainfall regarded as the most significant climate parameter affecting pastoralists' activities (Vogel, 2000) and its variability has significantly reduced land under pasture affecting production. Due to drought episodes, the number, distribution and productivity of permanent pastures and water points are likely to decline (Mureithi & Opiyo, 2010; Mkutu, 2001). Behnke & Scones (1993) observed that rainfall largely determines pasture availability in relation to grazing, directly impacting on ultimate livestock production in areas affected by drought. Drought induced displacement is shaped by grazing land, pastoralists ability to access it, herd sizes and composition, livestock marketing strategies, remittance flows, market prices and the scale and type of humanitarian interventions (Ginnetti & Franck, 2014). The present study further sought to adopt a socio-economic approach in investigating the effects of drought events on livestock production and appropriate strategies to enhance resilience to drought among the pastoral communities.

To sustain pastoral livestock production, Government, Non-Governmental Organizations and Community Based Organizations should play key role by creating awareness on how to adapt to rainfall variability and drought (Aberra, 2011) and more so be involved in resource mobilization to fund community-based projects such as borehole drilling, water harvesting and irrigation. This is to supplement rainfall and enable longer growing seasons for crops and pasture. There is also great need to develop effective early warning systems for pastoralists in ASALs (Jerie & Ndabaningi, 2011). Being able to adapt to drought closely links to vulnerability (Few, 2003). High levels of vulnerability and low adaptive capacity in the developing world have been linked to factors including reliance on natural resources, a limited ability to adapt financially and institutionally and lack of safety nets (Beg *et al.*, 2002).

According to Kaur *et al.* (2010), drought events have affected livestock water points influencing livestock productivity. Droughts events has led to reduced water sources especially in Arid and Semi-Arid areas leading to high demand for the scarce resource and conflicts among the pastoralist community (Agwata, 2006). Previous studies indicate that drought has led to the drying of rivers and residing of lakes in Baringo County, sparing very few surface water storages (Jenny & Svennson, 2002; Odada *et al.*, 2006). Studies have shown that water sources are sensitive to rainfall variability and prolonged drought with cases of fluctuating lake levels documented, indicating a negative impact of prolonged droughts on lake water regime (Boko *et al.,* 2007; World Bank, 2013). Both Lake Baringo and Bogoria have registered a significant retreat within the last decade following cycles of frequent and severe droughts hitting the arid and semi-arid lands of Baringo County (Boko *et al.,* 2007; World Bank, 2013). It therefore poses many challenges in water management practices that can guarantee sustainability and in some cases creating conflicts among communities that share resources (Kundzewicz *et al.*, 2008).

Chao and Peiwang (2005) identified a number of challenges to water resources in many countries. These include increasing and competing water demands; uncertainty caused by unpredictable climates; co-ordination of trans-boundary water resource management; water shortages in arid and semi-arid areas and absence of proper management of water resources. Rainfall varies over time and space, therefore affecting the waters sources differently and posing different challenges to water management in Africa (Conway *et al.*, 2009). Rainfall variability and drought affects pasture through limitation of soil moisture needed for pasture development (Carter & Parker, 2009; Kundzewicz & Doll, 2009).

The present study appreciates the role played by water resources in influencing livestock productivity in Arid and Semi-Arid areas and a major driver for adaptation options in the ASALs. Irrigation is one of the most commonly practiced and effective technology to buffer crop yields from weather anomalies in pasture management in dry lands. Irrigation can supply an alternative source of water to substitute deficient rainfall in terms of both quantity and timing (Howden *et al.*, 2007; Parry, 2007) and provides for deficiencies in soil moisture resulting from rainfall failure. Irrigation protects pasture irregularities and reduces the impacts of decreases in total rainfall on pasture and water for pastoral livestock production. Rainwater harvesting, with appropriate management and utilization, has potential to serve as an adaptation strategy to current rainfall variability and drought and supplement rain fed natural pasture production (Bewket, 2009). A study by Orindi & Murray (2005) on adaptation to climate change in East Africa called for the wider use of small-scale, low-technology solutions such as using rooftops and tanks to harvest and store water and encouraging people to use rain water for washing, bathing and watering gardens and livestock.

Education, experience and access to extension services or general information on inter-annual rainfall and drought increase the likelihood that farmers will perceive rainfall variability, drought and its impacts differently as these provide information about climate and weather (Maddison, 2007). This suggests that effects of rainfall variability and drought and livestock production are not based entirely on actual climate conditions and changes, but are also influenced by other factors (Gbetibouo, 2008; Bhusal, 2009; Mengistu, 2011; Elagib & Elhag, 2011), that the researcher must be keen to identify to guide in defining the appropriate adaptation strategies.

Other effects of drought include: Rise in food prices, fall in prices for some farm products, destruction of farming activities, water and fodder resource scarcity which leads to livestock mortalities, starvation and death of people (Little 1992; Begzsuren *et al.*, 2004; Doig *et al.*, 2006). Livestock prices during drought season are low and tend to discourage herders from disposing off their livestock due to overburdened supply to the market during later stages of drought that drive prices downwards (Bekure *et al.*, 1991; Swift *et al.*, 2002). The prices tremendously drop due to deterioration of the livestock body conditions causing herders to sell at very low prices to avoid total losses and lack of better alternatives of saving the herds (Barrette & Luseno, 2004).

Previous studies indicate that severe droughts occurred in 1984, 1980 and 1991/1992 claiming 64.8%, 42% and 33.6% of livestock respectively (Bollig, 2006; Ellis & Swift, 1988; Ellis *et al.*, 1987; Homewood & Lewis, 1987; Andassa & Oba, 2007; ILRI, 2010; Lesorogol, 2008). Droughts account for the highest livestock mortalities among the pastoral communities, some of which causes pastoralists to exit from the pastoral system, especially those who cannot rebuild their stock (McPeak & Little, 2005). The 2000/2001 drought raised stockless households from 7% to 12% in Northern Kenya affecting several households that depend on pastoralism of the sole source of livelihood (McPeak & Little, 2005). The 1999-2001 droughts in northern Kenya caused livestock losses values at US$ 77.3 million (Swift *et al.*, 2002). The severe drought of 2005/2006 led to 43% TLU mortality in Kitengela, Kenya (Nkedianye *et al.*, 2011). Severe drought snare associated with livestock market crashes and ultimately diminished purchasing power of pastoral households has subjected several households to abject poverty (Barrett & Luseno, 2004).

The country in the past has experienced an inverse relationship between drought severity and livestock prices. For instance, cattle prices dropped from Kenya Shillings 11,000 KES (110 USD) during the 1992 mild drought to 6,000 KES (60 USD) during the 1996 extreme drought while sheep and goats' prices dropped from 1,425 KES (140 USD) to 600 KES (60 USD) over the same period in Laikipia North and Bunyala (Huho & Kosonei, 2014). Musemwa *et al.* (2007) in a study to analyse cattle marketing channels used by small-scale farmers in the Eastern Cape Province of South Africa established through formation of farmers and marketing groups, farmers could be cushioned from low prices. Such groups are important among pastoral communities and need to be established where none exists. The groups enable the farmers to lower transaction costs, increase access to information and increase participation into the formal markets, thereby protecting them from exploitation of market and environmental hazards speculators (Musemwa *et al.*, 2007). Good prices at the time of destocking during times of drought provide the farmers with the capacity to restock when environmental conditions improve.

Variation of effects of drought in space and time and demand for location-based research informed the need for the present study. It therefore sought to establish the sensitivity of the pastoral community in Baringo County. This is significant in developing appropriate adaptation strategies to reduce vulnerability to drought among pastoral community in the study area.

2.5 Utilization of Seasonal Climate Forecasts in Securing Livestock Assets

Hansen *et al.* (2011) indicate that climate may not be easily predicted over long period. The length of time corresponds to the amount of error that affects accuracy of forecast. Farmers especially in the more Arid and Semi-Arid environments where rainfall variability and drought impacts most strongly on livelihoods, have developed coping strategies to buffer against the uncertainties induced by such events. Some of the coping mechanisms developed by governments, non-governmental institutions, pastoralists and other stakeholders to respond to rainfall variability and drought include maintaining food reserves; planting of drought resistant crops; and supply of relief food to households at risk of famine (Lesorogol, 2009; Bekure *et al.*, 1991; McPeak & Little, 2005). Education to minimize impacts of pastoral shocks, sale of livestock for slaughter, creation of a common market to purchase emaciated livestock during droughts and provision of veterinary services also forms part of the strategies (Akillu & Wekesa, 2002; Doig *et al.*, 2006; Saidimu, 2012; Deressa *et al.*, 2008; Yesuf *et al.*, 2008; Gbetibouo, 2008; Dhaka *et al.*, 2010; Mworia & Kinyamario, 2008).

According to Ebei *et al*. (2007), sheep and cattle are more sensitive to droughts than other livestock species while goats, donkeys and camels are more resistant to drought-induced stresses. Field (2005) observed that camels are drought resistant while small stocks breed rapidly so recover quickly from rainfall variability and drought induced stresses. According Field (1985) and Devendra (2005; 2011), small ruminants such as goats and sheep form an important economic and ecological niche in agricultural systems in developing countries. Their significance is related to adaptation to the environment, contribution to nutritional and food security and ease of conversion to cash for immediate family need.

World Society for the Protection of Animals (Knight-Jones, 2012) stresses on the importance of destocking and restocking as an adaptation strategy amongst the pastoral community, an approach informed through access and uptake of seasonal climate information. Restocking can impact on a family livelihood and future prospects (Knight-Jones, 2012). Lewa (2015) indicates that restocking is a significant response strategy to rehabilitate livelihoods after humanitarian disasters.

Reducing vulnerability to drought is major challenge to the pastoral community who accumulate large herds of cattle as a livelihood and social status security (Manoli *et al.*, 2014). They will therefore engage in long distance mobility as a means to save their livestock from effects of drought. Pastoral lifestyle involving movement of livestock and households from one area to another in search of pasture and water resources is one of the most adopted strategy to respond to drought in pastoral areas in Kenya (ILRI, 2010; Nkedianye *et al.*, 2011; Saidimu, 2012; McPeak & Barrett, 2001; Dyson-Hudson & McCabe, 1985). Nomadic households fully utilise forage resource, which varies in space, and time by shifting their livestock from one area to another (Coughenour, 2004; Thornton *et al.*, 2007a; Thornton *et al.*, 2007b; Butt *et al.*, 2009; Thornton & Herrero, 2008).

Livestock mobility is one of the widely practiced grazing management strategy with great results amongst the pastoral communities (Butt *et al.*, 2009). Encroachment on communal grazing lands, sedentarization, land fragmentation, land tenure constraints, livestock pests and diseases and conflicts affects mobility in pastoral lands (Morton, 2007). For success of livestock mobility as an adaptation to drought, pastoralists must be empowered with appropriate climate forecast information to inform their mobility decisions. Studies indicates that mobility can be very successful and more beneficial when drought is restricted to smaller areas or pockets surrounded by extensive areas of adequate pasture and water (Nkedianye, *et al.*, 2011). Proper timing enhanced with access and uptake of climate forecasts provides foundation for effective and successful livestock movement hence reducing losses.

Pastoralists engage in diversification of livestock species to spread risks associated with drought events (Manoli *et al.*, 2014). Climate information accessed by the community influence selection of livestock types in arid and semi-arid lands. Manoli *et al.* (2014) indicates that diversification act as savings accounts and provides security to recover from shocks of drought.

Diversification improves the pastoral community's capacity of the livestock herd to increase productivity (Manoli *et al.*, 2014). Other than livestock diversification, there is need to diversify sources of livelihoods. The extension officers can equip the pastoral community with appropriate information including climate forecast information to inform decision on alternative livelihood sources.

Some important contributions made in dealing with pastoral risks involve development of efficient forecasting models (Luseno *et al.*, 2003, McPeak & Little, 2005; Saidimu, 2012). Planning mitigation strategies mainly depends on prediction of expected event, effects of the forecasted event and value of the information (Luseno *et al.*, 2003). Frequency in which droughts seem to occur and the resultant impact influence forecasting and comparative evaluation of mitigation strategies (Abule *et al.*, 2005; Desta & Coppock, 2002).

There are different Models, approaches and technologies used to produce seasonal forecasts. European Centre currently uses coupled atmosphere-land-ocean models for Medium-Range Weather Forecasts (ECMWF) and National Centre for Environmental Prediction (NCEP) to produce seasonal climate forecast (Lavers *et al.*, 2009; Saha *et al.*, 2006). The integrated model combines the principle of sea surface temperatures associated with El Niño Southern Oscillation responsible for seasonal climate anomalies and production of an ensemble forecast (Lavers *et al.*, 2009; Guilyardi, *et al.*, 2009; Abram *et al.*, 2008). Scientific information such as climate forecasts, should always meet the perceived needs of the user population. Scientific climate information should be communicated in comprehensible manner and must be consistent with existing value of potential users (Thompson & Rayner, 1998; Gerlach, 1993).

Forecasting models predict the expected performance of the fodder in the ASAL as a tool in drought preparedness (Kaitho *et al.*, 2003; Swift *et al.*, 2002). The earliest scientifically based schemes are the India's Meteorological Department that has been involved in predictions of monsoon rainfall since the 19th century using statistical methods (Goddard *et al.*, 2003). The forecasts guide in the prediction of climate of given localities, providing the community ample time to prepare and respond to environmental dynamics. Climate simulations of the 20th century and projections models on average accurately predict the social, economic and environmental impacts of climate change and drought events, giving user's confidence in their role in adaptation strategies (Meehl *et al.*, 2009; Zhang & Delworth, 2006; Seager *et al.*, 2007).

Mathematical forecasting methods used in East Africa include Autoregressive Integrated Moving Average (ARIMA) modelling used to predict state of forage and Multiple Regressions used in predicting the slow-onset of food insecurity (Kaitho *et al.*, 2003; Mude *et al.*, 2009b; Saidimu, 2012).

These strategies are risk spreading in nature and designed to mitigate the negative impacts of poor seasons but usually fail to exploit the positive opportunities of average seasons (Cooper *et al.,* 2008). The livelihood assets that influence an individual's adaptive capacity include natural capital, social capital, human capital, physical capital and financial capital. The various capitals play a major role in generating strategies and variation in exposure to natural and socio-economic hazards. The natural capital is the level of diversity in an environment and it includes land and produce, biodiversity, environmental services, water and aquatic resources, trees and forest products and wildlife. The social capital involves the formal and informal networks, groups and institution. Examples include networks and connections such as patronage, neighbourhoods and kingship, relations of trust and mutual support, formal and informal groups, common rules and sanctions, collective representation, mechanisms for participation in decision-making and leadership.

Human capital is a function of knowledge (education), health, nutrition, the quality and quantity of available labour and capacity to adapt. Physical capital is the basic infrastructure, tools and technology that enables the pursuit of a livelihood. This include transport, secure shelter and buildings, water supply and sanitation, energy, communication, tools and equipment for production, farm inputs and traditional technology. Financial capital refers to the direct or indirect flows and stocks. Examples include savings, formal or informal credit, remittances, pensions and wages. The stronger, more resilient and more varied the asset base, the greater is the household's adaptive capacity and level of security and sustainability of their future livelihoods (DFID, 1999; Cooper *et al.,* 2008). According to Notenbaert *et al.* (2007); Eriksen & Lindi (2009), strengthening local adaptive capacity is a critical component of adapting to recurrent drought episodes. According to Lynam (2006), the most effective means to mitigate consequences of drought events is to increase the rate of agricultural growth and development, which is possible through appropriate decision making based on reliable data/information.

The present study takes keen interest in the use of seasonal climate forecast as an adaptation strategy to climate variability and drought events. Studies indicates that seasonal climate forecasts have several applications in different sectors both in developed and developing countries (Lemos & Drilling, 2007; Vogel & O'Brien, 2006; Meinke, *et al.*, 2008; Roncolli *et al.*, 2009; Gilles & Valdivia, 2009). Previous studies (Klopper, *et al.*, 2006; Washington *et al.*, 2006; FAO, 2013) indicates that seasonal climate forecasts if accessed at the right time and used well, are a potential tool that can assist pastoralists in coping and adapting to variable climate conditions. Ash *et al.* (2007) indicates that the main objective of seasonal climate forecasts among the pastoral community is to minimise losses associated with drought. Effective climate information services for the pastoralist communities involve improving information products, information services and delivery of those products.

Patt *et al.* (2005), in assessing effects of seasonal climate forecasts among subsistence farmers indicates that farmers who used the forecasts to make decisions realised significant yields, a finding that emphasise on the importance of seasonal forecasts in decision-making. According to Hansen *et al.* (2007), pastoralists can best use climate forecast information when: it is interpreted at a local scale and includes information about timing beyond seasonal climate means; expressed accurately in transparent and probabilistic terms; and can be interpreted in terms of impacts and management implications. Effective use of climate information requires translation of raw climate information (climatology, observations and predictions) into quantitative information (water status, pest or disease risk, vegetation and yields) with uncertainties expressed in probabilistic terms (Hansen, *et al.*, 2007).

Useful seasonal forecasts are those produced and disseminated with the user in mind as they aim at benefiting production if continuously and effectively used (Klopper, *et al.*, 2006). The communication of forecasts should be comprehensible to the end users, and addressing the local needs of pastoralists for whom the seasonal rains have critical importance (Thompson & Rayner, 1998; Gerlach, 1993; Lemos *et al.*, 2002; McIntyre & Phillips, 2000; Recha *et al.*, 2008). The present study sought to validate seasonal climate forecasts released by Kenya Meteorological Services.

According to Dilling and Lemos (2011), the context of potential use and process of scientific knowledge production influence usability of scientific knowledge. Lemos & Rood

(2010) indicates that the uncertainty normally faces shifts from usefulness to usability of climate projections. Usefulness regards to the scientists' perception of users' needs while usability involves users' perception of what knowledge is applicable to meet their immediate needs (Lemos & Rood, 2010). Scientists often make assumptions if what they think is useful and known to be usable, aspects that may be different from how the users define their needs. This calls for critical examination of the end user interest and the process of production, dissemination and access of scientific information, an objective accomplished by appropriate institutional arrangements and organisation. McCrea *et al.* (2005) indicates that putting considerable effort in developing seasonal climate forecasts and demonstrating the benefit of the forecasts to the target group encourages use of seasonal climate forecasts. McCrea *et al.* (2005) singles out three factors that influence uptake of seasonal climate forecasts among farmers. These include level of farmers understanding of forecasts; the format of presenting forecasts; and the farmers' attitude towards usefulness of the forecasts. There is urgent need to address these factors to increase uptake of the climate information amongst the pastoral community.

It is important to address the factors that influence the pastoralists' attitude towards usage of seasonal climate forecasts. Hayes *et al.* (2011) indicated that in order to reduce vulnerability to drought, it is critical to develop comprehensive drought monitoring system that provides early warning of drought onsets, determine drought severity, drought spatial extend and communication of climate information in real time.

According to Lemos *et al.* (2002), access to rainfall, forecasts and awareness do not translate directly into trust and use as the cultural factors affect the users' perception of forecasts. In a number of instances, pastoralists produce their own individual forecasts through reading and interpreting localized natural signs. Some even use local rain prophets whose prophesies is well disseminated and respected. Other constraints to implementation of forecasts are barriers to livestock mobility in times of drought, inaccessibility to forecast information, inability to access assets, labour, resources or ability to choose among alternate climate-sensitive technologies. Some pastoralists may also view probabilistic forecasts as unrealistic expectations and broken promises. Lack of resources among pastoral farmers critically limit their range of choice in terms of alternative options, technologies or cash generating activities (Patt & Gwata, 2002; Lemos, *et al.*, 2002; Recha *et al.*, 2008).

Rangeland constraints relating to land use majorly hamper mobility strategy (Saidimu, 2012). The major constraint is continually reducing land capacity productivity e.g. forage productivity is declining and species changing due to overexploitation (Tefera *et al.*, 2007). There is also constant permanent loss of pastoral rangelands due to privatization, gazettement for conservation and a high settlement in addition to the consequential contraction of land productivity in space and time due to degradation (Thornton *et al.*, 2006; Saidimu, 2012).

More constraints to utilization of seasonal climate forecast and planning for drought include the following: Politicians, policy makers and the public may lack an understanding of drought; in areas where drought occurs infrequently, governments may ignore drought planning or give it low priority. Governments may have inadequate financial resources; no single definition of drought applies to all regions; responsibilities divided among many governmental jurisdictions; most countries lack a unified philosophy for managing natural resources including water; and policies such as disaster relief and outdated water allocation practices may actually deter good long-term natural resource management. The present study sought to establish the utilization of seasonal climate forecast in securing livestock assets in Baringo County, Kenya. Livestock can make great contribution to climate-smart food systems through management of organic matter and nutrients, diversification of incomes and provision of highly nutritious animal protein.

Hansen *et al.* (2011) in a study to review seasonal climate forecasting for agriculture in sub-Saharan Africa established that the value of seasonal climate forecast cannot easily be economically quantified. The value can be determined through understanding of the impacts of climate variability and drought on agricultural decision-making and how the access of forecasts can benefit agricultural and pastoral activities. The study further indicates that high rates of uptake and benefit of seasonal climate forecast can effectively be realised in cases where extended interaction between researchers and farmers exist.

Elbers *et al.* (2007) suggests that the uncertainty associated with seasonal rainfall variability is the main driver towards accessing and managing the right climate information to reduce the direct cost. Farmers have a tendency of optimizing agricultural management and decision-making in the face of adverse climatic conditions in order to cushion them against catastrophic loss associated with climatic shocks, a pointer towards the value of seasonal climate forecast (Hansen *et al.*, 2009; Barrett *et al.*, 2004). A study by Phillips *et al.* (2002) found out that widespread response to seasonal forecasts has a likelihood of increasing average cereal production in Zimbabwe. This finding is an increase that access to seasonal climate forecasts has a positive correlation with production. Thornton *et al.* (2004) using an ecosystem simulation model in Northwest Province, South Africa established that reducing livestock numbers in El Niño increased average simulated income substantially for the livestock farmer. Seasonal climate forecast can play a major role in decision-making regarding adjustment in the herd size to respond to predicted climatic conditions.

Studies have laid emphasis on the benefits and values of seasonal climate forecast to pastoralists (Barrette, 1998; Hulme *et al.*, 1992; Blench, 1999). These studies indicates that pastoralists encounter loses due lack of predictability of climate at local level, inability to change management options due to lacks appropriate forecasts and inability to accommodate risks associated with wrong forecasts or lack of it. These findings expose the value of seasonal climate forecasts in pastoral livestock management.

2.6 Policy and Institutional Framework for Better Utilization of Seasonal Climate Forecasts

2.6.1 Current Products and Delivery Mechanisms

Several institutions in place help improve generation, dissemination, access and utilization of seasonal climate forecasts and early warnings, aimed at improving resilience to effects of rainfall variability and drought events in the world, Africa and Kenya. Potential institutions are also in the pipeline based on the dynamic nature of droughts, new technologies of addressing drought events and partnerships that are continuously developed increase individual country's capabilities of fighting drought events and associated impacts.

The sub-Saharan Africa (SSA) depends on uncertain rainfall and exposure to climate risks that influence agricultural production (Hansen *et al.*, 2011). The SSA has through history depended on Regional climate outlook forums (RCOFs) to produce and disseminate seasonal climate forecasts (Ogallo *et al.*, 2008). RCOF with the support of World Meteorological Organization (WMO), WMO Global Producing Centres and other international climate centres bring together National Meteorological Services to develop, distribute and discuss potential application of consensus forecast of rainfall and other variables. The forum at times provides training to seasonal climate forecasters on new approaches and technologies (Hansen *et al.*, 2011). African Centre of Meteorological Application for Development (ACMAD) in 1997 initiated Radio and Internet for the Communication of Hydro-Meteorological and Climate Related Information (RANET), with objective of providing climate information to remote communities in Africa (Boulahya *et al.*, 2005).

The fight against drought and desertification receives a high priority in the long-term plan of the WMO. WMO involves the National Meteorological and Hydrological Services, regional and sub-regional centres and other bodies in the improvement of hydrological and meteorological networks for systematic observation, exchange and analysis of data, promote weather forecasts and monitor drought. There are 6 Regional Associations (RA): RAI – Africa, RAII – Asia, RAIII – South America, RAIV – North and Central America, RAV – Southwest Pacific and RAVI – Europe of WMO established working groups that focus to identify the impacts of drought. They help identify strengths and weaknesses of government actions in water and drought management (World Meteorological Organization [WMO], 2005). Their overall objective is to reduce vulnerability to drought events and related effects.

The Global Drought Early Warning Monitoring Framework (GDEWF) and Global Drought Early Warning System (GDEWS) aims at improving existing regional and national drought monitoring and forecasting capabilities by incorporating global scale, improving continental monitoring and forecasting and empowering the national and regional institutions engaging in early warning systems but lacks the capacity (Pozzi *et al.*, 2013; Ali, 2012; Verdin, 2012). This approach demands for global partnership between countries with capacity and those without to enable transfer of appropriate technologies at cheaper, efficient and affordable terms. The global approach that incorporates global drought forecasting and early warning systems, real time drought monitoring and harmonised methods to identify critical areas vulnerable to drought events has the capabilities of reducing vulnerability to drought in arid and semi-arid lands (Pozzi *et al.*, 2013; Ali, 2012; Verdin, 2012). The elements of a global drought early warning system include drought early warning - reducing vulnerability to environmental hazards by providing the users with relevant information with appropriate framework to implement mitigation measures;

and global observing system for drought – identify drought data sources and requirements. Global drought forecasting – capabilities to forecast drought components within monthly, seasonal, inter-annual and decadal precision; global drought information integration and delivery – ability to consolidate all drought information to formulate a solid basis for operational drought monitoring relevant for individual country's needs (Pozzi *et al.*, 2013).

WMO, The United Nations (UN) and Convention to Combat Desertification (UNCCD) focus on promoting developments of national drought policies and integrated drought management. Their objectives include: effective monitoring and warning systems aimed at providing real-time information to users; effective impact procedures; proactive risk management measures; and preparedness plans aimed at increasing resilience to drought and associated impacts (Pozzi *et al.*, 2013; Johnson *et al.*, 2006; Winslow *et al.*, 2011; The United Nations Convention to Combat Desertification [UNCCD], 2003). WMO and the Global Water Partnership Integrated Drought Management Program (IDMP) through agreements during Geneva conference on 11th - 15th March 2013, have the mandate to develop drought knowledge base geared towards improving resilience and reducing vulnerability to drought events (Pozzi *et al.*, 2013).

The European Union Seventh Framework Global Water Scarcity Information Service (GLOWASIS) aims at improving seasonal meteorological and hydrological forecasting through use of advanced data monitoring (GLOWASIS, 2013; Pozzi *et al.*, 2013). GLOWASIS maps sites of global water scarcity and stress. The United Nations Development Programme (UNDP) has supported several major initiatives in the ASAL areas including support for the Arid Lands Resource Management Programme II. These global institutions provide a platform with the ability to reduce uncertainties associated with lack of adequate data for monitoring drought, they improve access and speedy delivery of relevant climate information thereby increasing the user's resilience and reducing impacts of drought.

Other institutions established with the aim of planning monitoring strategies include Arid Lands Resource Management Project (ALRMP) and Drought Management Initiative (DMI), which develop Early Warning Signs (EWS) in Kenya. They publish monthly bulletins indicating the state of environmental conditions; Livestock Early Warning System (LEWS) assess the long-term forage production, the effect on the livestock body conditions and productivity. Famine

Early Warning Systems Network (FEWS-NET) provides early signs on food security; Livestock Information Network and Knowledge System (LINKS) provides advisory services to the pastoral communities in East Africa on the forage conditions and the impending famine for appropriate herd management (Kaitho *et al.*, 2003; Arid Land Resource management Project [ALRMP], 2007b; Saidimu, 2012). The institutions in general, aim at enhancing the adaptive capacity of the pastoralists in ASALs. Pozzi *et al.* (2013), indicates that most countries especially developing countries lack adequate resources required for provision of early warning information for risk management. This calls for external support by donor countries to increase the capacity of developing countries.

2.6.2 Policy Framework for Better Utilisation of Seasonal Climate Forecasts

Adoption of the ASAL policy in Kenya is an achievement in terms of institutionalization of appropriate policy responses to the marginalization and underdevelopment of the arid and semi-arid lands in Kenya. RoK (2011) indicate that, the ASALs, pastoralism and the Northern Kenya present a set of unique potentials and challenges to the development of Kenya and more so have distinct but overlapping policy implications. This calls for a united front in solving their challenges. The ASAL policy reinforces other policy options articulated in Kenya Vision 2030, The Constitution of Kenya 2010, The National Land Policy (2009), The Integrated National Transport Policy (2010), The Water Act (2002), The National Policy for the Sustainable Development of Northern Kenya and Other Arid Lands (2012) and The National Disaster Management Policy (2012). Other policies include The Kenya Forestry Master Plan (1995-2020), The National Environmental Policy (2012), Environmental Management and Coordination Act (EMCA 2015), The National Environmental Action Plan (2009-2013), Kenya National Climate Change Action Plan (2013-2017), Climate Change Act 2016 and National Climate Change Response Strategy (NCCRS) (2010). All these policies, action plans and strategies aim at enhancing the resilience of the ASAL people, among other citizens, to climate change and associated drought events (RoK, 2002; RoK, 2005; RoK, 2009; RoK, 2010a; RoK, 2010c; RoK, 2011; RoK, 2012a; RoK, 2012b; RoK, 2012d; RoK 2016).

The Vision 2030 main seeks to attain a secure, just and prosperous Northern Kenya and other arid lands where people achieve their full potential and enjoy a high quality of life (RoK, 2007; RoK, 2011). The Northern Kenya is the gateway to the growing market in the Horn of

Africa. Its livelihood establishment, cultures and natural resources has a significant contribution to the national economy and therefore the region cannot be ignored (RoK, 2007; RoK, 2011). The vision 2030 development strategy for Northern Kenya and other arid lands focuses on the distinct opportunities and challenges of arid and semi-arid lands (RoK, 2011). The strategy aims at addressing problems facing the ASALs, for example; effects of climate change, drought, insecurity, and legacy of past underdevelopment among others in order to realise its potentials (RoK, 2007; RoK, 2011). The strategy lays foundation for developing intervention measures that can help uplift ASALs to the level of other parts of the country.

The vision 2030 strategy formulates options for protecting Kenya citizens by effectively managing risks associated with drought; improving the enabling environments for growth, development and environmental management. The Vision 2030 developing strategy seek to identify, document, protect indigenous knowledge and technologies aimed at increasing resilience of the ASAL communities to environmental hazards such as drought (RoK, 2013a). In pursuit to generate and implement appropriate adaptation strategies to challenges facing the arid and semi-arid communities, the vision 2030 provides basis for strengthening institutional capacities in science, technology and innovation for the development. It focuses on strengthening livestock health systems in ASALs, investing in necessary foundations to support livestock production and marketing, encourage the growth of sustainable bio-enterprise production and marketing. Promotes integrated rangeland resource management and support development of added value within the livestock sector, promote integrated and conservation-based farming, encourage the quality and reach of technical support, encourage opportunistic farming where appropriate, support appropriate irrigation technologies and approaches (RoK, 2007; RoK, 2013a; Watson & Binsbergen, 2008). This aspect singles out vision 2030 as one of the best frameworks for utilisation of seasonal climate forecasts. It provides the need for access and uptake of seasonal climate forecasts and options for responding to drought events and a framework to solve the challenges facing ASALs in Kenya.

The Constitution of Kenya 2010 provides an affirmative action to redress historical marginalization of the ASALs and provides a strong grounding for the ASAL Policy of 2012. It aims at ensuring equitable sharing of national and local resources throughout Kenya. Article 204 creates an Equalization Fund that aims at harmonizing the quality of basic services e.g. water, education, electricity among others with those enjoyed by other parts of the country. Article 63 strengthens communal land rights that are critical for the functioning of the pastoral communities of the ASALs (Ochieng', 2013; RoK, 2010a). The Constitution of Kenya, 2010 provides a platform for formulation and implementation of legislations on adaptation and mitigation strategies to climate change and drought. Article 42 and 43 of the constitution guarantees each citizen a clean and healthy environment, economic and social rights that promise good health. Article 56 provides for affirmative action programmes for the marginalised groups while article 63 provides for management of community land, an aspect that touches on the ASAL community (RoK, 2010a; RoK, 2012b).

The goal of National Land Policy (2009) is to lay a strong foundation for sustainable development of the ASALs (RoK, 2009; RoK, 2010a; RoK, 2012a; Ochieng', 2013). The objectives include: to manage public land in Kenya on behalf of the National and Government; conduct research related to land and the use of natural resources and make recommendations to appropriate authorities; and to monitor and have oversight responsibilities over land use planning throughout the country. The main goal of the policy is to retain the health and integrity of land resource in Kenya, which may include aspects of drought management (RoK, 2009; RoK, 2010a).

The National Disaster Management Policy (2012) set to achieve the following set objectives: identify disaster sub-regions, evolve strategies for the sub-regions, integrate a national strategic plan, harmonise Disaster Management for all disasters, provides for coordination of all Disaster Management-related activities, and promote continuous stakeholder consultations with relevant line Ministries, to enhance co-ordination of interventions. It promotes partnership with stakeholders for improved action; promote and facilitate co-ordination and access to synthesised information for Disaster Management; promote mass education and functional literacy in environment, Disaster Management and Climate Change, in collaboration with the Ministry in charge of formal education. The policy promote mass sensitisation and awareness creation on Disaster Management and Climate Change for the general public; promote and stress the urgent need for sustainable mainstreaming of Disaster Management and Climate Change into Development Planning and Management, to promote poverty alleviation and sustainable development. It encourage promotion, domestication and implementation of Kenya's ratified international, regional and sub-regional Agreements, Conventions and Treaties, which relate to Disaster Management (RoK, 2012b). These objectives tend address issues related to climate drought.

The Integrated National Transport Policy (2010) aims at consolidation of urban public transport system through introduction of appropriate mass transport transit system, integration of planning, design and development of non-motorised and inter-mediate means of transport infrastructure into development of and operation of transport infrastructure to address the needs of the poor. These objectives are critical in establishing transport system that does not threaten the health of the environment and reduce acceleration and effects of drought events. Efficient transport network provides an avenue for implementation of alternative options of responding to drought events.

The Water Act (2002) aims at achieving the following: determine the requirements of the reserve for each water resource; classify resources; identify areas, which should be designated protected areas and ground water conservation areas (RoK, 2002). This act recognises the role played by water resources in influencing the livelihoods of societies in relation to drought and other environmental hazards.

The National Policy for the Sustainable Development of Northern Kenya and Other Arid Lands focuses on issues which are distinctive of ASALs and which required specific responses (RoK, 2012a). The policy is in line with international agreements and treaties e.g. the Desertification Treaty (RoK, 2012a). The ASAL policy seeks to achieve the following objectives: provide a framework for ASAL development coordination, resource, mobilization, research, monitoring and evaluation; strengthen cohesion and integration of ASAL with the rest of the country and address inequality including gender, youth and vulnerable groups. It targets to improve the enabling environment for development in the ASALs by establishing the necessary foundations for development and bridge development gaps; develop alternative approaches to service delivery in pastoral areas and provide a policy framework for enhancing synergy on ending drought emergencies. The policy promotes sustainable utilization of existing land and land based resources to facilitate national economic development; to provide an enabling environment for sustainable agriculture, livestock, trade and tourism development in the ASALs (RoK, 2010a; RoK, 2012a)

The National Environment Policy (2012) goal is to provide a better quality of life for current generation without compromising the quality of life of the future generations through sustainable management of the environment and natural resources (RoK, 2012c). The policy seeks to provide a framework for an integrated approach to planning and sustainable management of Kenya's environment and its natural resources; strengthen the legal and institutional framework for effective coordination and management of the environment and natural resources; ensure sustainable management of environment and natural resources for economic growth and improved people's livelihood and well-being. Promote and support the use of innovative environmental management tools and promote and enhance cooperation, collaboration, synergy, partnerships and participation in the protection, conservation and better management of the environment by all stakeholders (RoK, 2012c). To manage the environment effectively as envisioned, several institutions must work in partnership. The activities involve acquisition of relevant environmental information and problems that that guides in finding relevant solutions. Seasonal climate forecast can be one of the sources of information relevant in solving problems facing citizens (RoK, 2007; RoK, 2012c). The policy provides legal framework that guarantees the relevance of institutions that generate environmental information such seasonal climate forecasts. The policy spells out the various approaches and technologies appropriate in addressing environmental hazards such drought (RoK, 2012c).

The objectives of The National Environmental Action Plan (2009-2013) include facilitating the optimal use of national land and water resources in improving environmental quality; promote sustainable use of natural resources; and consider environmental conservation and economic development as integral parts of the same process of sustainable development. The action plan being a component of the national environment policy provides a framework though which relevant environmental information such seasonal climate forecast is accessed and utilised. It provides relevance to access of prudent environmental information (RoK, 2012c).

The Environmental Management and Coordination Act (EMCA 1999) subjects all proposed projects likely to have negative impacts on the environment to Environmental Impact Assessment (EIA). The act defines the role of Environmental Impact Assessment (EIA) as a tool that guarantees a clean and healthy environment. Under sections 58 and 138 of the EMCA act, EIA report must be prepared and submitted to the National Environment Management Authority

(NEMA) for review and licensing of development projects. The act therefore aims at protecting the environment, including the arid and semi-arid lands (RoK, 2010a; RoK, 2012d). The assessment may demand and/or incorporate climate information from respective locations therefore laying emphasis of access and uptake of the information. In pursuit to assure citizen of a clean and healthy environment, the act provides a platform and condition for access and utilization of climate forecast information in areas earmarked for development. Accessing all relevant information relating to the area in question provides an avenue for sustainable development.

The Kenya Forestry Master Plan (1995-2020) and Forest Act 2005 places emphasis on the establishment of forest-based programmes as an avenue for implementing forestry development activities in the country. The programmes are location based and in some cases aimed at rehabilitating various areas in Kenya including but not limited to ASALs. The plan and act aims at development of technologies relevant for rehabilitation of waters towers in Kenya. For implementation of the objectives of the act and plan, climate forecast information is of necessity. The plan/act therefore provides a strong basis for rehabilitation of ASALs, access and utilisation of seasonal climate forecasts (Kenya Forestry Research Institute [KEFRI], 2013; RoK, 2005).

Kenya National Climate Change Action Plan (2013-2017) aims at operationalisation of Kenya's strategy and international obligation of ensuring a climate resilient and low carbon nation (National Climate Change Action Plan [NCCAP], 2012). The Action Plan provides for concrete mitigation, adaptation interventions and enabling conditions required for effectively responding to climate change. The Action Plan aims at enabling Kenya reduce its vulnerability to climate change and associated effects such drought. With its objective to take Climate Change Action Plan to the next stage of implementation, analysis and enabling mechanisms, it stands out an enabling institution for aces and utilization of seasonal climate forecast. The Action Plan's components of low carbon resilient development, enabling policy and regulatory framework, adaptation and mitigation and development of enablers such as knowledge management and capacity building provides a foundation through which efficient access and utilization of seasonal climate information can be assured. The plan aims at reducing vulnerability to climate change and drought in ASALs among other areas (NCCAP, 2012). The Plan has the potential of improving adaptive capacity of communities through improved access to information and services and reducing vulnerability to disasters such as drought by using climate risk information (NCCAP, 2012). Implementing NCCAP demonstrates Kenya's commitment to obligations of United Nations Framework Convention on Climate Change (UNFCCC) and enables the country attract international partnerships and investment in innovative sustainability programmes (NCCAP, 2012). The partnership provides avenues for the country accessing modern technologies in generation, dissemination and utilisation of climate forecast information that meets the need of the end-user. The NCCAP's adaptation analysis indicates that the key climate change impact in Kenya is drought and water scarcity (NCCAP, 2012). These are the two main environmental hazards that affect ASALs and negatively impacts on the livelihoods of the pastoral communities.

The Climate Change Act of 2016 domesticates all national and international laws, regulations and treaties regarding climate change in Kenya. The Act provides framework for administering climate change fund, sets the targets for regulation of greenhouse gas emissions. It provides analytical support on climate change in various sectors of the economy and environments and provides for formation of a directorate that serve as the national knowledge and information management centre for collating, verifying, refining and disseminating knowledge and information on climate change and other related environmental phenomenon. The Act also provides for avenues through which collaboration with other agencies develop strategies aimed at building resilience to climate change and enhancing adaptive capacity (RoK, 2016). These make the Act a vital institution for enhancing access and utilization of seasonal climate information and resilience of pastoral communities in ASALs.

The ASAL policy removes the stigma that has always bedevilled the ASALs since colonial time in Kenya. Some of these moves that led to isolation of the ASALs include: The Outlying District Ordinance of 1902 and Special Districts Ordinance of 1934 that restricted movement in and out of the ASAL's; The Sessional Paper No.10 of 1965 that focused national economic development strategies towards agriculture and investing in the "high potential areas" (Ochieng', 2013; RoK, 1965). According to RoK (2003), the Economic Recovery Strategy for Wealth and Employment Creation highlighted the potential of the ASAL's in livestock production, fishing, mining, tourism development, trade and industry (RoK, 2003). On the other hand, Kenya Vision 2030 three pillars are relevant to addressing the core livelihoods and development challenges in ASAL. Vision 2030 recognizes the importance of livestock production in the ASALs and seeks to exploit the potential for the benefit of the region. The social pillar seeks to create a just, cohesive and equitable social development in a clean and secure environment, a vision of inclusion that aims at integrating ASALs into national development (RoK, 2007).

The National Climate Change Response Strategy (NCCRS) (2010) target to address the challenges associated with climate variability and change (RoK, 2010c). The vision of the strategy is to develop a country resilient to climate change and associated impacts such as drought. It aims at strengthening mitigation and adaptation measures in responding to climate change challenges. NCCRS objectives include enhance understanding of the global climate change regime; access the evidence and impacts of climate change in Kenya; identify the most effective and efficient adaptation and mitigation strategies to climate change; improve understanding of climate change and its impacts nationally and within the region. It recommends vulnerability assessment, impact monitoring and capacity building framework needs as a response to climate change; recommend the country's research and technological needs in relation to climate change and impacts. The strategy recommends a conducive and enabling policy, legal and institutional framework to combat climate change; and provide a concerted action plan combined with resource mobilisation plan and monitoring and evaluation plan to combat climate change (RoK, 2010c). The objectives of NCCRS (2010) aims at improving the resilience of the Kenya's people with regard to climate change and associated effects such as drought that is threatening the livelihoods of the ASAL people. The achievements of objectives and goals of the strategy is possible proper or improved generation, dissemination, access and uptake of climate forecast information. NCCRS (2010) therefore lays a strong foundation for utilization of seasonal climate forecasts in ASALs in order to reduce vulnerability of the pastoral community.

The ASAL policy affirms government commitment to the development of ASALs and its integration into the national economy. It singles out the extent of inequality between the ASALs and the rest of the country and the benefits of integrating the ASALs into the national economy. The policy highlights the potential of the ASALs in terms of strategic position, trade, livestock, tourism, natural wealth and pastoralists experience in managing climate variability. The policy focuses on quest for rapid development and need to maintain and support unique livelihoods systems that but utilizes the variable ecological conditions of the region (Ochieng', 2013; RoK, 2012b).

The goal of the ASAL policy is to facilitate and fast-track sustainable development in the ASALs by increasing investment in the region and ensuring that the use of those resources is fully reconciled with the realities of people's lives. One of the objectives of the policy is to strengthen the climate resilience of communities in the ASALs and ensure sustainable livelihoods. The policy seeks to strengthen the resilience of ASAL communities to drought and other climate related disasters. Of great interest for this study is its target on drought management and climate change, land and natural resource management, livestock production and dryland farming (Ochieng', 2013; RoK, 1965; RoK, 2007; RoK, 2010a; RoK, 2012a). The present study is in tandem with the objectives of the policy options on management of drought events as it aims at identifying and classifying droughts, strengthening adaptation options with an aim of reducing the pastoralists' vulnerability to drought events and its effects.

Davies *et al.* (2009) indicates that the best approach to make social protection resilient is by reducing dependence on climate sensitive livelihood. Swanson (2006) in examining the changing role of agricultural extension in global economy established that the extension systems play a vital role in alleviating rural poverty, reducing hunger and enabling small-scale farm households in developing countries improve their livelihoods. Developing the sector well can help reduce vulnerability of pastoralist communities in Arid and Semi-Arid lands. Putting the National policies in place can help strengthen these institutions. The extension officers should assist pastoral farmers to be organised, identify their immediate needs regarding access and uptake of climate forecast information and training farmers on adoption of innovations. Extension officers have a role to play in empowering pastoral farmer in identifying prevailing market conditions, problems and solutions, all in pursuit to reduce farmer's vulnerability during drought events (Musemwa *et al.*, 2007). Based on the current governance organisation under the Kenya Constitution (2010), the county governments, should recruit competent extension officers and adequately fund them to facilitate their assigned activities. It is on the basis of the above policy frameworks that timely, accurate, and seasonal climate forecasts that factor the user's needs can be generated and its uptake enhanced to reduce vulnerability of the pastoral communities.

2.6.3 Policy and Institutional Barriers to Access and Uptake of Seasonal Climate Forecasts

Different studies have highlighted barriers that limit access and uptake of seasonal climate forecasts (Lemos *et al.*, 2002; Glantz, 1977; Barrett, 1998; Hulme *et al.*, 1992). The barriers can be associated with inadequate infrastructure and governance (Glantz, 1977), lack of predictability of climate at farm scale (Barrette, 1988) or inadequate policies and institutional processes (Hansen *et al.,* 2011; Cash *et al.*, 2003). To confront challenges compromising efforts to use climate related information aimed at improving lives of smallholder farmers and pastoralists, studies have identified five important aspects to be taken into consideration (Lemos *et al.*, 2002; Glantz, 1977; Barrett, 1998; Hulme *et al.*, 1992; Hansen *et al.*, 2011; Cash *et al.*, 2003; Tall *et al.*, 2014). These include;

Salience: This aspect demands for downscaling of climate information to farm level. Salience entails establishment of institutional arrangements at the local level to support interaction between the forecasters, agricultural organisation and pastoralists. It also incorporates delivery of seasonal climate forecast at a local scale relevant to pastoral unit or farm decision making, and forecasts and early warnings that enables pastoralists or farmers to manage evolving risks through seasons (Tall *et al.*, 2014; Hansen *et al.,* 2011).

Legitimacy: This involves incorporation of agricultural knowledge and the farmers' or pastoralists' knowledge in generating climate forecasts. Integration of scientific climate information with indigenous knowledge is option towards establishing legitimacy of forecasts as it helps build trust, local relevance ad use (Hansen *et al.,* 2011; Tall *et al.,* 2014).

Access: This can be enhanced through establishment of forums for face-to-face dialogue between pastoralists and disseminators of seasonal climate forecasts (Hansen *et al.,* 2011; Tall *et al.,* 2014). This can be in form of seminars, workshops, trainings and use of information and communication technologies (Tall *et al.*, 2014).

Equity: women and other marginalised groups should be involved in the generation and dissemination of seasonal climate forecasts. Access can be influenced by gender, wealth and ethnicity (Tall *et al.*, 2014). According to Roncolli *et al.* (2009), the marginalised Burkina Faso ethnic groups and women had problems accessing climate forecast information. Equity ensures that each group is given opportunity to present their climate information needs and therefore an opportunity for satisfaction.

Integration: Seasonal forecasts should entail both the climate services and interventions within the broader national and local level. The forecasts should be delivered be delivered as a full package of agricultural support and development assistance that provides option for pastoralists and farmers to act on the information (Hansen *et al.,* 2011; Tall *et al.*, 2014).

2.7 Summary of Gaps in Literature

Analysis of climate parameters is a useful framework for decision-making and in-depth understanding of climate variability and past drought events. This is can help improve drought mitigation and preparedness and therefore reduce vulnerability. The current study therefore sought to analyse drought trends and severity in Baringo County.

Previous studies recommended a shift from blanket generalisations and solutions of impacts of climate change and drought on livelihoods to case-focused studies aimed recommended mapping drought vulnerability at smaller administrative subdivisions within countries. This is aimed at generating scientific knowledge base for operational drought tools such as drought monitoring and warning signs forming part of national drought preparedness plans. The current study acknowledged that drought effects vary in space and time and therefore sought to fill this gap by carrying out location-based study on effects of drought events in Baringo County.

Several studies have recommended the need to move from crisis management to risk management approaches and use of available drought monitoring tools to reduce impacts of drought. This involves development of drought information systems that incorporates real-time information to improve adaptive capacity of the pastoral communities because restocking period is becoming shorter. The forecasts though routinely disseminated, they have not yet been integrated effectively into pastoralism development and therefore a new and unexploited innovation of assessing access and use of forecasts. The present study sought to address this problem by assessing the effectiveness and usefulness of seasonal climate forecasts in the arid and semi arid Baringo County.

Studies have established that seasonal climate forecasts if accessed at the right time and used well, are a potential tool that can assist pastoralists in coping and adapting to variable climate conditions. More so, useful seasonal forecasts are those produced and disseminated with the user in mind, emphasising users' perception of what knowledge is applicable to meet their immediate needs and not the scientists' perception of users' needs. The present study sought to address the problem facing access and uptake of seasonal climate forecast among the pastoral community of Baringo County by determining the barriers and enabling conditions to use of seasonal climate forecasts.

2.8 Theoretical Framework

The study is conceptualised on the theoretical framework of basics information theory that information can enable people to cope with uncertainty (Hirshleifer & Riley, 1992; Luseno *et al.,* 2003). When faced with uncertain future that affect the relative productivity of their livelihood base, pastoralists will use climate forecast information to resolve temporal uncertainties by making resource allocation choices. Based on this theory, several crucial questions arise that are relevant to assessing the value of climate forecast information in addressing vulnerability of pastoralists to drought events.

The crucial questions to address include:

i. Does the pastoralist understand the language of climate forecasts?

With reference to the present study, it was important to address pastoralists' capacity to understand probabilistic climate forecasts. At times, a barrier may result from the language used or the level of skill of the pastoralists. Scientists should take into consideration and interrogate the language needs of the end-users and not necessarily, what they themselves perceive as the need. Extension officers in the target locations can help facilitate this.

ii. What sort of prior beliefs do prospective users hold with respect to climate patterns?

The theory provides for appreciation of indigenous knowledge among pastoralist. Pastoralists will ignore new information if they have confidence in indigenous climate forecasts. It is therefore important to guide pastoralists to embrace new information and if possible, incorporate it with indigenous knowledge. United Nations Environment Programme (UNEP, 2008) indicates that indigenous knowledge is a traditional cultural knowledge that includes intellectual, technological, ecological and medical knowledge. Traditional local communities have continued to rely heavily on indigenous knowledge to conserve the environment and deal with natural disasters (UNEP, 2008; Lewa, 2015; Nyong *et al.*, 2007).

iii. Who receives external forecasts?

This principle informed the study in the sense that information is of no value to those who do not receive it, hence the need to assess the availability, effectiveness and efficiency of the enabling institutions. Dissemination of forecasts should take into consideration the end user of the information. There is need to establish appropriate institutions to facilitate the dissemination of new knowledge.

iv. What confidence do recipients have in external forecasts?

The theory provided a guidance that if pastoralists have no confidence in the new information, then they will not embrace the new information. This principle helped in assessing usage of seasonal climate forecasts among the pastoralists of the Arid and Semi-Arid agro-ecological zones of Baringo County. There is need to build the pastoralists confidence in the seasonal climate forecast information. Pastoralists must appreciate the significance of forecasts information for uptake of new technology to be improved.

v. Is the external forecast different from the pre-existing indigenous forecasts?

This tenet helps understand that pastoralists will update their beliefs on condition that the seasonal climate forecasts released by Kenya Meteorological Services differ from prior information. It is important to guide pastoralists to establish the existing differences. Local communities have always been using the indigenous knowledge. They appreciate it and will cling to it unless a clear-cut significance of the alternative approve is exposed to them. Where possible, there should be an integration of scientific forecasts with the traditional climate forecasts.

vi. How does receipt of and confidence in external forecasts affects users' subjective probability distributions over climate?

These questions guided the study to appreciate that if the pastoralists are slow to update their prior beliefs in response to new seasonal climate forecasts, then it may require a number of forecasts to make them change their beliefs and action. It is also important that underlying factors that prevent uptake of climate forecasts are established and addressed.

vii. How do pastoralists' posterior beliefs over uncertain climate affect their decisions and with what consequences for their welfare?

This depends fundamentally on pastoralists' material and non-material preferences with respect to risks, conformation to or deviation from community norms, incentives and constraints on their needs. Users of forecasts should appreciate the fundamental reasons behind the climate forecast information. Establishing and improving enabling institutions is significant in improving uptake of the new technology among the pastoral community.

In general, the basics information theory provided a solid foundation for the present study and guidance in understanding that it requires novelty, confidence, ability and willingness to embrace seasonal climate forecasts in securing livestock assets.

2.9 Conceptual Framework

The conceptual framework (Figure 2.1) displays the relationship between the four research questions and interactions between the independent, intervening and dependent variables. Drought events are the target climate related hazards with adverse effects on livestock assets of which the magnitude is a resultant of planned adaptation strategies that pastoralist implemented. There are seasonal climate forecast that provide early warning information, which can inform implementation of planned adaptation to reduce loss of livestock assets during drought events. However, seasonal climate forecast may not predict the observed drought events with reasonable probability. The expectation is that high predictability of observed drought events with the relayed climate information forecasts support active implementation of planned adaptation actions. However, how households in practice use the seasonal climate forecast is likely to be facilitated by household conditions and enabling policy and institutions as they influence knowledge of and access to seasonal forecasts.

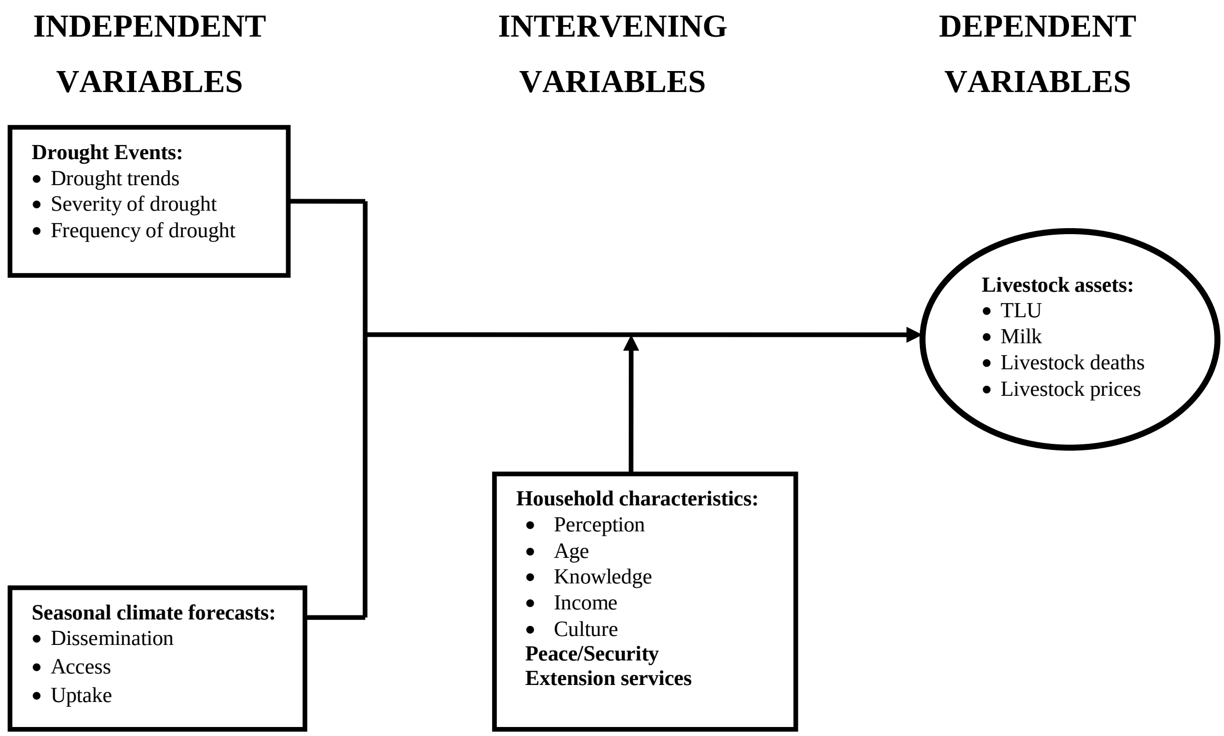


Figure 2.1

Conceptual framework showing relationship between drought events, seasonal climate forecast and drought effects on livestock assets

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

The study was in Baringo County in Kenya (Figure 3.1). The choice of Baringo County was on the criteria that it is arid and semi-arid lands experiencing recurring drought events (Guha-Sapir *et al.*, 2012; Guha-Sapir *et al.*, 2013; RoK, 2013b).

3.1.1 Geographic Location and Size of the Study Area

Baringo County is in the Rift Valley, between longitudes $35^0 30^l$ and $36^0 30^l$ East and between latitudes $0^0 10^l$ South and $1^0 40^l$ North. The landmass is an area of 11,090 Km^2 of which 165 Km^2 is covered by surface water (RoK, 2013b, RoK, 2014).

3.1.2 Physical Features of the Study Area

Baringo County has altitude between 3000 m and 700 above mean sea level at its highest and lowest points respectively. The County has lakes including Baringo, Bogoria and Kamnarok. Indigenous forests cover parts of Kabarnet, Kabartonjo, Tenges, Lembus, Saimo and Ol' Arabel and Eldama Ravine.

3.1.3 Climatic Conditions and Vegetation of the Study Area

The County is classified as arid (Inner Lowland 6) and semi-arid (Lower Midland 5) (RoK, 2013b, RoK, 2014, Jaetzold et al, 2011). The LM5 and IL6 are the main agro-ecological zones of interest for the present study. The zones are too dry for rain-fed agriculture and experiences weak short rainy seasons. The evaporative demand is very high in the zones (Jaetzold *et al.*, 2011).

Temperatures range from a minimum of 10 ^{0}C to a maximum of 35.0 ^{0}C with bimodal rainfall pattern of long rains (MAM) and short rains (OND) which range from 300 to 700 mm in the lowlands and 1200 mm in the highlands (Jaetzold *et al.*, 2011; RoK, 2010b; RoK, 2013a). The short rains experienced in the months of October, November and December display a high inter-annual variability compared to the long rains received in March, April and May (Hastenrath *et al.*, 2007). The vegetation comprises of desert shrubs with drier thorny acacia trees and thorny bushes, except in the Southern part of the county where small patches of grasslands with temperate forests and evergreen forests of semi deciduous bushes and woods cover the land (Homewood & Lewis, 1987).

3.1.4 Demographic Attributes of the Study Area

The County has a population of 555,561 persons consisting of 279,081 males and 276,480 females in 110,649 households (RoK, 2010b; RoK, 2014). The average population density is 50 persons per square kilometre, with distribution influenced by climatic conditions, topography, soil composition, infrastructure and land ownership (RoK, 2010b; RoK, 2014). The dominant community is the Tugen with minority communities of Illchamus, Turkana, Kikuyu and Nubians.

3.1.5 Socio-economic Characteristics of the Study Area

Livestock assets are central in the livelihoods whether in pastoral, agro-pastoral, mixed and marginal farming systems in the County. The main livestock in the County are the East African Zebu cattle in the lowlands and exotic cattle in the highlands. The crops grown in the county are Maize, finger millet, sorghum, beans, cowpeas, green grams, Irish potatoes and sweet potatoes (RoK, 2014). However, the County has challenges of insecure access and control of land resource, increasing negative impacts of climate change and drought. The socio-economic conditions in the large part of the drier regions expose the population to resource-based conflicts on land, water, pasture, and low literacy level (Kipterer & Ndegwa, 2014).

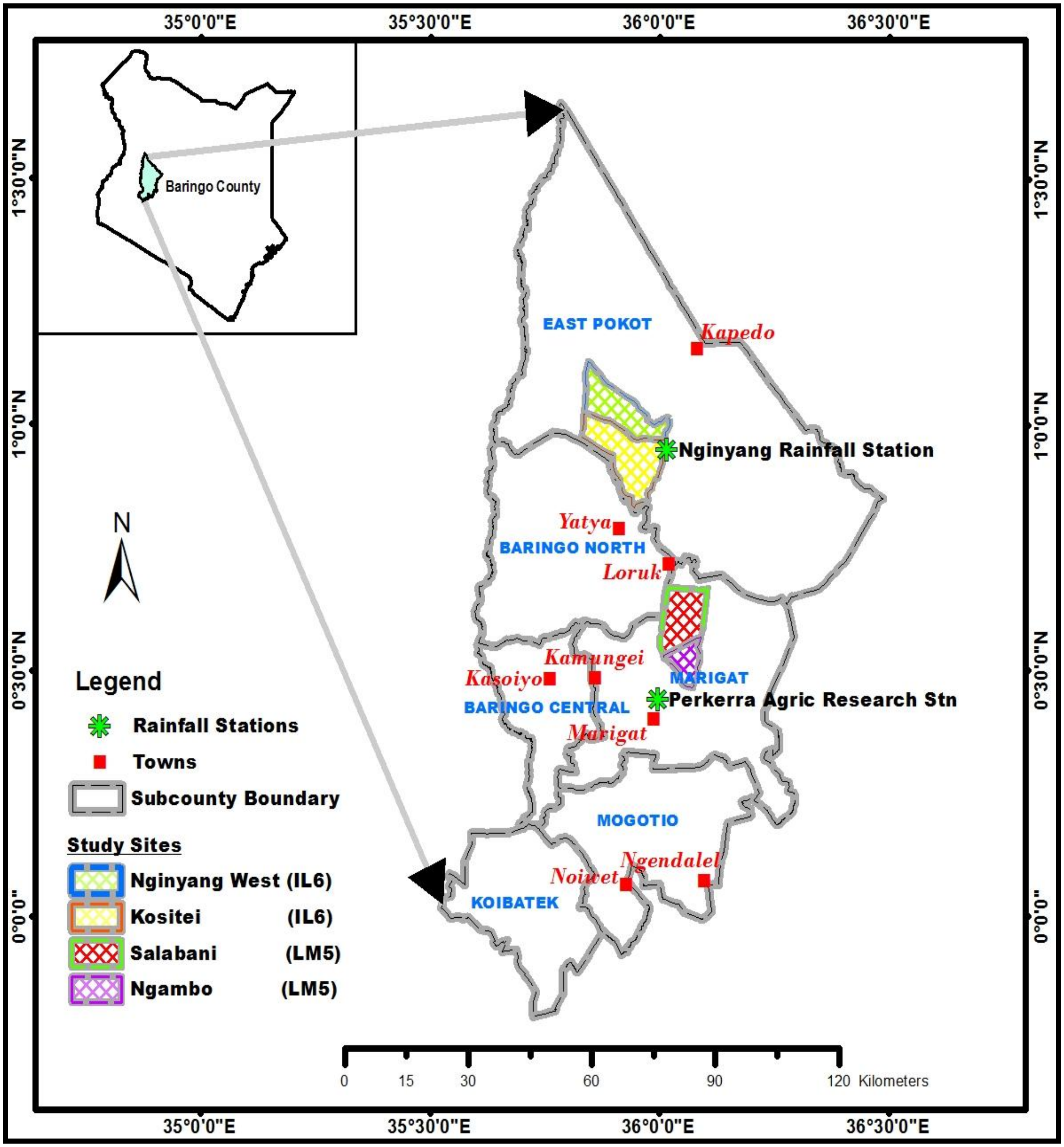


Figure 3.1

Map of Kenya showing study locations and rainfall stations

Source: Modified from Jaetzold *et al.* (2011)

3.2 Research Design

The study used cross sectional survey design to collect primary data from pastoral households. The design was preferred to capture different variables at a specific point in time and enabled researcher to obtain data on several issues with considerable flexibility during analysis. It is faster in data collection compared to case-controls and provides a relatively less costly opportunity to collect data from a large population (Kothari, 2004). Complementary data to survey included data from key informant interviews on livestock and drought management interventions and secondary data.

3.3 Sampling and Sample Size

The household was the sampling unit. In the target study locations with 1984 households, a sample of 221 was estimated using the formula (Krejcie & Morgan, 1970):

$$S = \frac{[x^2NP(1-P)]}{[d^2(N-1) + x^2P(1-P)]}$$ ………………………..……………….. Equation 1

Where:

s = required sample size

N = the population size (1984)

x^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

P = the population proportion (0.5)

d = the degree of accuracy expressed as a proportion (0.05)

The household survey covered four locations, stratified by agro-ecological zones (LM 5 and IL6) that are the semi-arid and arid lands region of the county. The four locations were Kositei and Nginyang West in the agro-ecological zone IL6, and Salabani and Ngambo in the agro-ecological zone LM5. In each location, the sample households were proportionately allocated to population (Table 3.1). The study use referral (snowball) sampling technique to pick the 221 households in the study location. The technique was preferred because of the migratory nature of the respondents, making it difficult to develop a comprehensive sampling frame that comprises of inaccessible part of target population. Through assistance of the informants, the researcher picked the first respondent who displayed the qualities of interest for the study (pastoralist). The first contacts directed the researcher to subsequent contacts displaying similar characteristics until the final sample target was achieved in each study location (Bhattacherjee, 2012).

Table 3.1

Sample population allocation by agro-ecological zones

Study locations	**AEZ**	**Household Population**	**Sample**
Kositei	IL6	331	37
Nginyang west	IL6	720	80
Ngambo	LM5	588	66
Salabani	LM5	345	38
Total		**1984**	**221**

Source: Adapted from RoK, 2010b

The study used MAM and OND seasonal forecasts for the years 2005 to 2015 which was the only accessible datasets at NDMA and KMS and recall data on perceived effects of drought on livestock assets for the period 2011 to 2015 (5-year period) because accuracy of recall data is lost if it spans over a longer period. Livestock asset data collected included milk production, livestock owned, livestock deaths and livestock prices for the period 2009 – 2015, based on availability of datasets of interest at the Ministry of Agriculture, Livestock and Fisheries and NDMA. Data on averages of livestock assets were available for the period 2009-2013, milk production (January to December 2013 – 2015), livestock owned (January-December 2015), livestock deaths (January-December 2015) and livestock prices (January-December 2014-2015) for the entire pastoral zone of Baringo County. Key informants who included Livestock officer and NDMA personnel provided supplementary data related to the research questions.

3.4 Data Collection

The study obtained data from households using structured questionnaire, from key informant using interview schedule and from secondary sources. The household survey data spanned over a recall period of 5 years about the perceived effects of drought events, utilization of seasonal climate forecast, livestock assets and the conditions enabling utilization of seasonal climate forecasts. Household and databases of the Ministry of Agriculture, Livestock and Fisheries and NDMA provided data on livestock assets.

The data from key informant interviews were on livestock assets and drought management interventions. The experts in key informant interviews were from the National Drought Management Authority (NDMA) and the Ministry of Agriculture, Livestock and Fisheries. Secondary data was sourced from NDMA and Kenya Meteorological Services, research working papers and journals on effects of drought on livestock assets, early warnings and MAM and OND forecasts for the period 2005-2015 from NDMA and the Kenya Meteorological Services. Livestock asset data were milk production for January to December 2013 – 2015; livestock owned from January-December 2015; livestock deaths from January-December 2015, livestock prices from January-December 2014-2015 and averages for the period 2009-2013 based on the assets of interest. Secondary rainfall data was for the period 1970-2008 and 1974-2013 from Perkerra (LM5) and Nginyang (IL6) weather stations respectively.

The data on livestock owned was converted into Tropical Livestock Unit (TLU), a conversion of livestock numbers into a common unit. The conversion factors are cattle = 0.7, sheep = 0.1, goats = 0.1 while camel = 1 (FAO, 1986; Jahnke *et al.*, 1988). The data was descriptively analysed to establish the effects of drought on livestock assets. Apart from the TLU, the study used actual numbers for the various livestock types.

3.5 Validity and Reliability

The questionnaire was pilot-tested with 50 respondents among the pastoralists of Kapedo West in Ribkwo Location within the Baringo County. The Cronbach's alpha coefficient was estimated from the data in order to assess validity and reliability of the instrument for data collection (Cirignotta *et al.*, 2002). The rainfall data from the two weather stations had missing rainfall data for which imputation method was then used to fill those missing values to eliminate gaps in the data set.

This is a requirement of World Meteorological Organization for climatological analysis. In this study, multiple imputations method was used to overcome underestimation of standard errors and confidence intervals typical of single imputation (Radi *et al.*, 2015). This method replaces missing data with substituted values from the observations of rainfall (rainfall data sets) at the same station and period but in different years.

The missing rainfall data P*x* was estimated using the following formula:

$$Px = 1/n \sum_{i=1}^{i=n} Pi$$ ………………………………………………………. (Equation 2)

Where:

n = the number of rainall data sets

P*i* = rainfall data from the ith data set

P*x* = missing rainfall data

3.6 Data Analysis

3.6.1 Determination of Drought Events

The standardized anomalies were computed from rainfall data using the formula:

$$SA\,(t) = \frac{\{SP\,(t) - \mu\}}{\{\sigma\}}$$ ………………………………………………………… Equation 3

Where:

SA (t) = time-series of standardized anomalies

SP (t) = cumulative precipitation during the season

μ = mean

σ = standard deviation

Categorisation of Standard Anomalies used World Bank (2013) definition as follows::

Anomaly lower than -0.9	*Anomaly between -0.9 and -0.6*	*Anomaly above -0.6*
Catastrophic drought	Severe drought	Not severe

The plot of indices generated time series graphs, drought events trends and severity within the study period. The assessment of relationship between the total annual rainfall and the annual drought indices – SA (t) was with correlation analysis and graphic plot.

3.6.2 Determination of Effects of Drought Events on Livestock Assets

The study used two data sets, household and Ministry of Agriculture, Livestock and Fisheries and NDMA. The mean comparisons, frequency distributions and percentages were analysed to establish the observed and perceived effects of drought on livestock assets. A linear regression models was fitted for livestock asset variables - TLU, livestock owned, livestock price and milk production being dependent on rainfall amount in the form $y = a + bx$ with y being a livestock asset, x the amount of rainfall for a given month, a intercept and b represents the change in y for a unit change in x.

3.6.3 Determination of Effectiveness and Usefulness of Relayed Seasonal Climate Forecasts for Predicting the Observed Drought Events

The effectiveness of the forecasts (*e*) in predicting the observed drought events was computed from Table 3.2 and 3.3 to assess the validity of the seasonal forecast information to inform planned adaptation actions. The indicator measures computed were:

Effectiveness = A / (A+C)

Positive predictive value (*ppv*) of the seasonal forecast representing the usefulness of the forecast information in giving early warning about drought events = A / (A+B)

In the formula, the variables are defined as:

A = Number of times that drought occurrence was predicted and was subsequently observed during the study period (True positive)

B = Number of times that drought occurrence was predicted but was not observed during the study period (False positive)

C = Number of times that drought was not predicted but was observed during the study period (False negative)

D = Number of times that drought was not predicted and was not observed during the study period (True Negative)

Table 3.2

Computation of the effectiveness and usefulness of climate forecast in predicting the observed drought events during MAM season

Predicted (Relayed forecasts)		Observed Drought Events: Yes	No	Total
	Positive	A (TP) = 6	B (FP) = 2	A+ B = (TP +FP) = 8
	Negative	C (FN) = 1	D (TN) = 2	C+D = (FN + TN) = 3
	Total	A + C = 7	B + D = 4	A+B+C+D = 11

Source: Adapted from Zhu *et al.* (2010)

Table 3.3

Computation of the effectiveness and usefulness of climate forecast in predicting the observed drought events during OND season

Predicted (Relayed forecasts)		Observed Drought Events: Yes	No	Total
	Positive	A (TP) = 4	B (FP) = 3	A+ B = (TP +FP) = 7
	Negative	C (FN) = 1	D (TN) = 3	C+D = (FN + TN) = 4
	Total	A + C = 5	B + D = 6	A+B+C+D = 11

Source: Adapted from Zhu *et al.* (2010)

The effectiveness value computed represent the proportion of actual observed climate events that the forecast correctly predicted. The measure gives an indication of the ability of the forecast to predict the observed climate events. The effectiveness value indicates the probability of the forecasts to predict occurrence of climate events. The higher the effectiveness value, the less likely failure is to observe the predicted event (Zhu *et al.*, 2010). The usefulness is the predictive value of the forecast represented by the proportion of forecast of drought events observed. The present study computed the two measures (Table 3.2 and 3.3) to establish the association between the predicted and observed drought events.

3.6.4 Determination of the Barriers and Enabling Conditions to Better Utilization of Seasonal Climate Forecasts

The frequency and mean computations were computed to determine the main barriers and enabling conditions to uptake of seasonal climate forecasts. Variables with percentage response computations greater than 50% were extracted as the most significant variables that facilitate or hinder uptake of seasonal climate forecasts as this comprises more than half of the respondents for each study variable. Analysis of variance determined if significant differences existed between the mean ranking of the hindrances to use of seasonal climate forecast and enabling conditions for dissemination, access and uptake of seasonal climate forecast information.

Table 3.4

Summary of Data Analysis

Objective	Independent variables	Dependent variables	Data sources	Analysis
Characterising trends and severity of drought events	• Rainfall	• Standardised anomalies • Drought index	• KMS • NDMA	• Time series • Correlation tests • Drought index analysis
Determination the effects of drought events on livestock assets	• Drought events	• TLU • Milk production • Livestock deaths • Livestock prices	• Household survey • Reports • KMS	• Mean comparisons • Linear regression
Assessment the effectiveness and usefulness of climate forecast in predicting the observed drought	• Forecast drought events • Knowledge • Access to SCFs • Type of forecasts	• Observed drought events • Usage of seasonal climate forecasts	• Household survey • Reports • KMS	• Sensitivity analysis • Correlation tests • Chi square test
Identification enabling conditions for utilization of seasonal climate forecast	• Barriers to SCFs • Facilitative conditions to SCFs • Traditional climate information	• Usage of seasonal climate forecasts	• Household survey • Reports	• Mean comparisons • Analysis of variance

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results and discusses the findings on trends and severity of drought events, their perceived and observed effects on livestock assets, the effectiveness and usefulness of seasonal climate forecast in predicting drought events, and conditions enabling better utilization of the seasonal climate forecast.

4.2 Reliability of the Tool and Response Rate Results

The questionnaire was pilot-tested with 50 respondents among the pastoralists of Ribkwo Location before being administered to a sample of 221 households in four study locations: Kositei (37), Nginyang west (80), Salabani (38) and Ngambo (66) in which Kositei and Nginyang west were categorized as IL6 while Salabani and Ngambo were categorized as LM5 . The reliability of the questionnaire was 0.835 Cronbach's alpha coefficient, indicating a good validation of the instrument reliability (Cirignotta *et al.*, 2002). The rainfall data spanning over 30 years had only less than 10% of data missing, which is satisfactory to the requirements of World Meteorological Organisation for climatological data analysis (WMO, 1992). The study used imputation method to fill missing rainfall data and to eliminate gaps in the data set.

4.3 Socio-economic Characteristics of Respondents

Table 4.1 is the distribution of sample households by relationship of respondent with household head and by education levels. The respondents in the primary data collection were seven in ten cases (73%) the household heads themselves and four in ten (42%) had no formal education while three out of ten cases (31%) had attained only primary school level education. Therefore, responses were from the informed members of the household, which should provide accurate and reliable information. The illiteracy levels were high (42% had no formal education) which may impede uptake of SCF to inform planned drought adaptation strategies needed to reduce vulnerability. Low skills and knowledge can worsen vulnerability to climate change among pastoral communities. Among the Somali nomadic and pastoralist communities, vulnerability to drought was high where there had been no access to either primary school or non-formal education classes for at least 3 years with only a few (5%) of young men having accessed formal education (Paavola, 2008; AET, 2014).

Table 4.1

Percent (%) distribution of the sample by relationship of the respondent with household head and by education levels

Respondent's relation to household head	**Education level**				**Total**
	No formal education	Primary and below	Secondary	Post-secondary	
Household head (Self)	32.6	22.2	14.0	4.5	73.3
Wife	7.7	5.4	2.3	1.4	16.7
Others	1.4	3.6	3.2	1.8	10
Total	41.6	31.2	19.5	7.7	100

Source: Field Data, 2016

The results (Table 4.2) show that males (77.4%) were dominant over females (22.6%) among the sample households in the study area. Kaimba *et al.* (2011) had observed that male-headed households were more likely to keep larger livestock herds whereas those with higher-level education were more likely to keep smaller herd sizes. The authors attributed this to knowledge that well educated have about the grazing capacity of the land, however, it may also be attributed to access to more diversified livelihood alternatives, which reduce dependency on livestock asset base.

Table 4.2

Percent (%) distribution of the sample gender of the household head

Gender	**Frequency**	**Percent (%)**
Male	171	77.4
Female	50	22.6
Total	**221**	**100.0**

Source: Field Data, 2016

The heads of the households (Table 4.3) were aged between 18 and 70 years with the majority (60%) being in middle age (31-50 years). This observed age distribution corresponds to those previously observed among the Ethiopian pastoralists (Melaku *et al.*, 2013) whose livelihood is livestock assets. Among these pastoralists, young men engage in livestock husbandry at age of 18-20 years while the elder men (≥ 50 years) play role of decision making over management of the livestock assets (Ssenkaaba, 2015; Cirignotta *et al.*, 2002).

In the present study, majority of the households (97.3%) were pastoralist. Only the few remainder (2.7%) engaged in non-pastoral activities, mainly trade and salaried employment with the county government and NGOs (Table 4.3). The interventions to stabilise livelihoods here thus have to target sustainable pastoralism.

Table 4.3

Percent (%) distribution of sample (n = 221) by age groups and engagement in pastoralism livelihoods

Age of household head (years)	Pastoral activities (%)	Non-pastoral activities (%)
< 18	0.5	0.0
18 - 30 years	21.3	1.4
31 - 40 years	36.7	0.45
41 - 50 years	22.6	0.45
51 - 60 years	9.5	0.45
≥ 61 years	6.8	0.0
Total	**97.3**	**2.7**

Source: Field Data, 2016

As is the practice in pastoral area, land ownership was communal (93%) and decision-making was by the elders. This governance system allows for equal rights of joint ownership by members of the community, and it secures access to grazing pastures and water resources (Table 4.4).

Table 4.4

Percent (%) distribution of respondents' land tenure

Type of Tenure	**Frequency**	**Percent** (%)
Own purchased	1	0.5
Inherited	13	5.9
Leased	1	0.5
Communal	205	92.8
Government land	1	0.5
Total	**221**	**100.0**

Source: Field Data, 2016

The livestock asset livelihood in this sample was characterised by mixed herds (Table 4.5) of cattle, goats and sheep (72 to 93%). A mixed herd of large and small ruminants is an adaptation strategy in times of drought. Maina (2014) reported that a pastoral household in Kajiado arid and semi-arid County, keeps on average 28 cows, 114 goats/sheep, 3 donkeys and 100 poultry. In addition to meat and milk diet, livestock assets are source of employment (90%) and income (95%) (Huho & Mugalavai, 2010; Babagana & Leyland, 2008). A household can easily liquidate sheep and goats for income towards building pastoral resilience during droughts.

Demombynes & Kiringai (2011) observed that more than half (58%) of all the households in the horn of Africa, covering seven drought-affected countries own at least 50 livestock, of which goats and sheep are the largest proportion. Diversification in livestock species is buffer in times of drought because they have different vulnerability levels to drought. According to Dahl & Hjort (1976), a pastoralist requires between 10-15 cows per adult in a household during regular dry season to meet family food demands. Based on an average of 5.02 members per household in Baringo Country (KIRRA, 2014), this translates to a minimum of 50 cows per household. Bekure *et al.* (1991) established three wealth classes to which pastoral household can belong. These include poor for those who own less that 5 TLU per Active Adult Male Equivalent (AAME) (less than 25 TLU per household), medium for households who own between 5 and 12.9 TLU per AAME (25-65 per household), and rich, households with more than 13 TLU per AAME (more than 65 TLU per household). Based on the two studies, most households in the present study area fall among medium wealth group with TLUs between 25 and 65 per household.

Table 4.5

Frequency distribution of households by livestock assets ownerships

Number of stock	Cattle	Goats	Sheep	Camel	Donkeys	Poultry
1 – 10	35	13	51	7	1	15
11 – 20	37	30	29	4		21
21 – 30	27	36	40	2		10
31 – 40	12	26	28			4
41 – 50	8	29	14			1
51 – 60	5	13	11			
61 – 120	1	42	31			
Total number of households	**125**	**189**	**204**	**13**	**1**	**51**

Source: Field Data, 2016

4.4 Observed Drought Events in Baringo County

The annual rainfall data obtained from the local meteorological stations in the study area were the basis for establishing the drought events observed during 1970 – 2013 period in the LM5 and IL6 agro-ecological zones.

4.4.1 Annual Rainfall Trends

Rainfall records between 1970 and 2008 had a general declining trend with four marked peaks in 1977, 1988/89, 1997 and 2007 and marked low mean annual rainfall below 23.0 mm recorded in 1984, 2000 and 2002 in LM5 (Perkerra, Figure 4.1a). The low mean rainfall records are periods of drought events associated with extreme climatic events (Huho & Kosonei, 2014), and the trend suggest that recent droughts have re-occurred with shorter interval time than was in the past.

Drought events reoccurring with more frequency within shorter intervals are already observed in several African countries including Burkina Faso, Ghana, Mali, Togo and Volta Basin (Kasei *et al.*, 2010). This is disruptive to livestock asset based livelihoods and therefore necessitates urgent implementation of planned adaptations strategies to secure livestock assets. The finding calls dissemination of climate information to the pastoral community can inform preparedness against climatic shocks and associated effects.

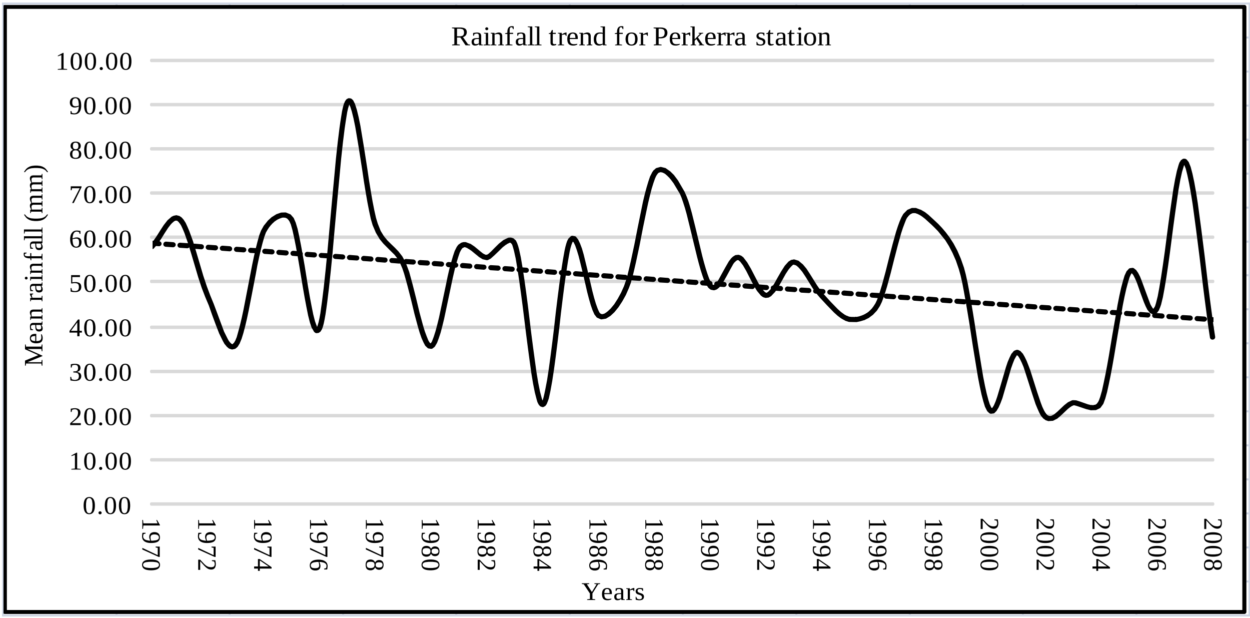


Figure 4.1a

Mean annual rainfall for LM5 - Perkerra rainfall station

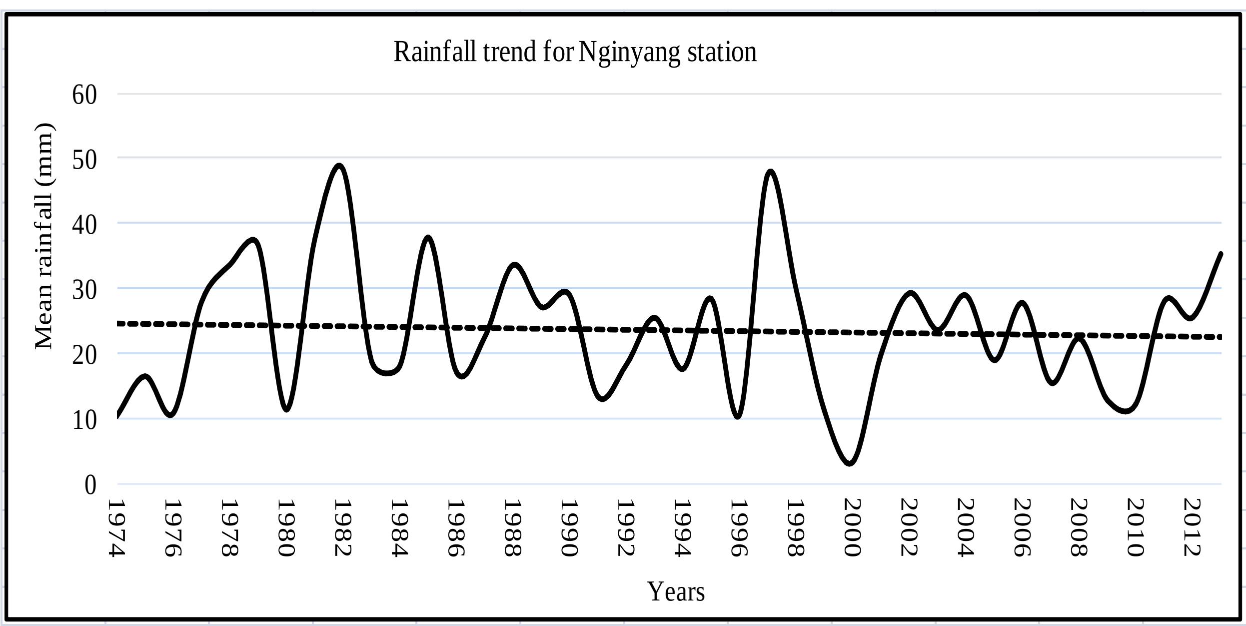


Figure 4.1b

Mean annual rainfall for IL6 - Nginyang rainfall station

A general decline in rainfall was observed in IL6 zone between 1974 and 2012 (Figure 4.1b) at Nginyang rainfall station with oscillating trend having peak rainfall in 1982 and 1997, and others in 1979, 1981 and 1985. Low long-term annual mean rainfall of 23.52 mm is associated with extreme climatic events and in the study area, very low rainfalls (3.29 to 13.33 mm) far much below the long-term annual average featured in 1974, 1976, 1980, 1991, 1996, 1999, 2000 and 2009 corresponding to years of widespread drought experienced in Kenya (Huho & Kosonei, 2014). Results do indicate that the area has become drier over time and more vulnerable. The period that Nginyang registered very low rainfall corresponds to reported (Vicente-Serrano *et al.* (2012) periods of drought events in Congo in the 1970s, 1980s and 1990s years, which is an indication that drought can be widespread and cut across international boundaries. In that case, trans-national planned adaptation actions become necessary to respond to recurring droughts.

4.4.2 Severity of the Observed Drought Events

Figure 4.2 is a plot of the annual drought index for the observed drought events in LM5 and IL6 agro-ecological (the annual Standardized Anomaly values in relation to the drought severity in these areas are in Appendix III and IV).

On a time-scale of 12-month (annual), for the period 1970 – 2008, four extreme catastrophic drought periods were observed in 1984, 2000, 2002 and 2004 with standard anomalies less than -0.9 ($SA(t) < -0.9$) as a function of the time scales in LM5 (Figure 4.2a). Other noticeable catastrophic drought events were in 1972/1973, 1976, 1980, 1986, 1995/1996, 2001, 2003, 2006 and in 2008. With the exception of year 2003 and 2008, the observations concur with those of Huho & Kosonei (2014) on the occurrence of extreme climatic events in Kenya. The 2003 and 2008 cases can be attributable to locational variation in drought events in place and time. Similar findings of catastrophic droughts were recorded in Morocco, Algeria and Tunisia in 1984 and 1999-2003 (Ouassou *et al.*, 2007; Touchan *et al.*, 2008; Touchan *et al.*, 2011). These reports are indication of the spatio-temporal nature of drought events. The drought events experienced in Baringo County were also being experienced elsewhere as well in other parts of Africa. The concurrence of these findings indicate that similar drought events can be experienced in different locations and therefore the current study findings can be implemented in other ASAL regions in Kenya.

Noticeably, all the catastrophic drought events were preceded by high rainfall events (Standard Anomalies greater than 1, SA(t)>1.00) and this phenomenon takes place when the sea surface temperature in oceans increase anomaly, causing sudden heavy rainfall and thereafter rainfall decreases drastically followed by a prolonged severe dry spell (Fyfe *et al*., 1999). The effects emerge in two forms, increasing then suddenly decreasing rainfall amount. For instance, the El Niño rains in 1997 - 1998 classified as the worst El Niño effect in 20th century preceded catastrophic drought event in 2000 – 2004 period. The obtained drought indices show breaks between successive drought events in the study area. The period between successive droughts provides pastoralists with an opportunity in restock or invest more in livestock. Deeper insight into the drought trends is a sure way of reducing the pastoralists' vulnerability to droughts and associated impacts.

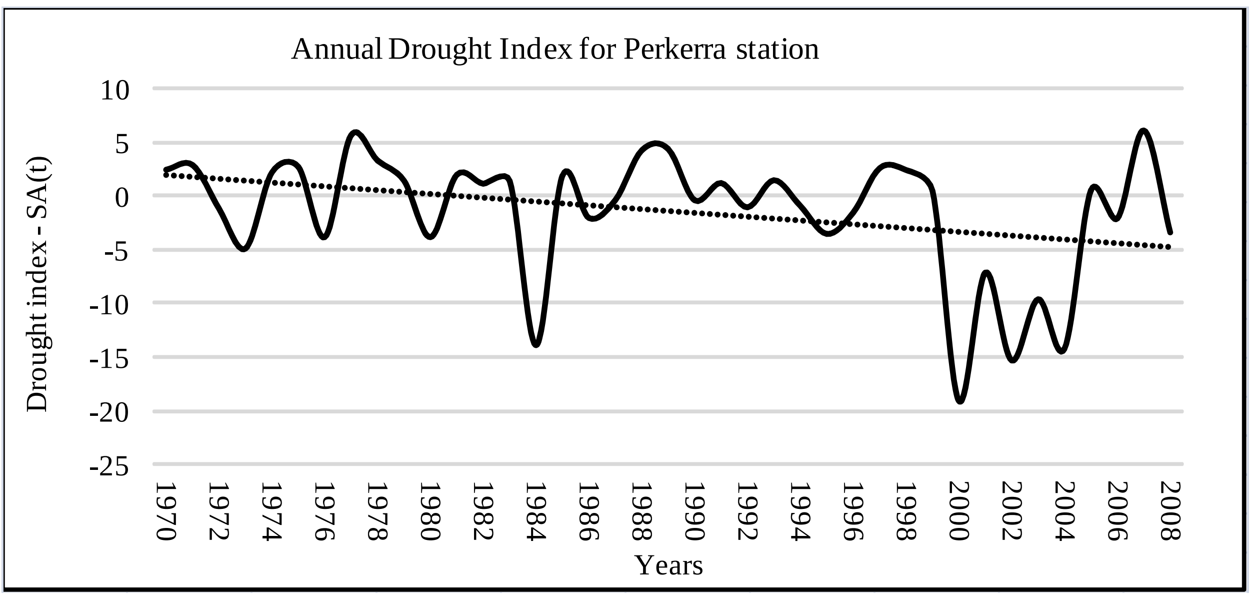


Figure 4.2a

Annual drought index for LM5 zone - Perkerra rainfall station

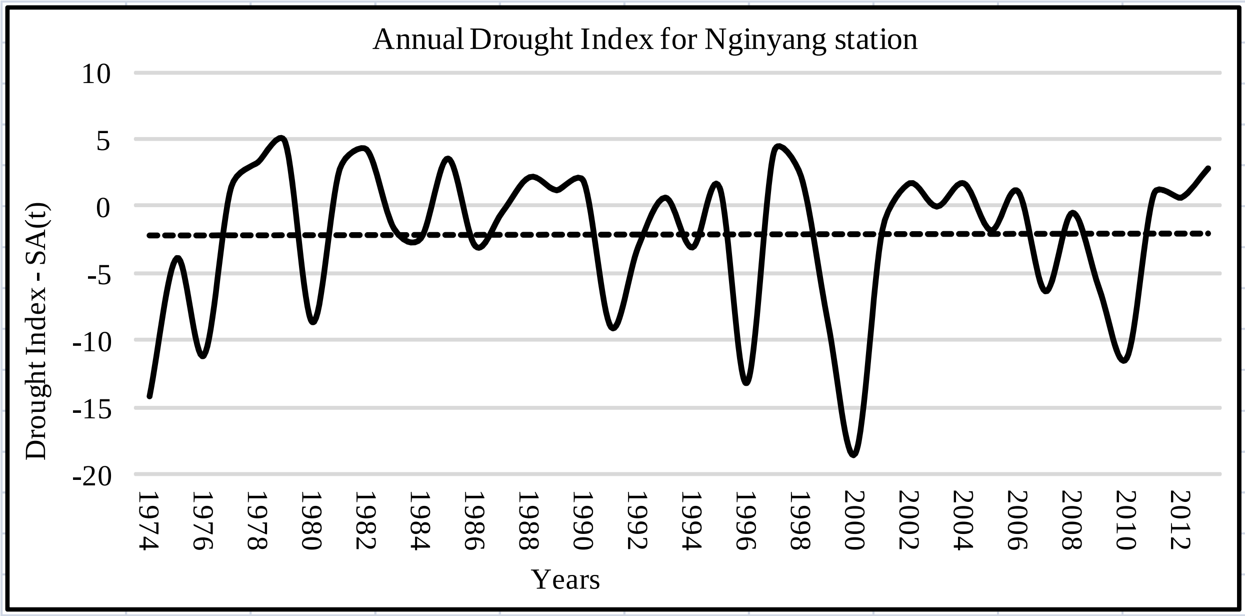


Figure 4.2b

Annual drought index for IL6 zone - Nginyang rainfall station

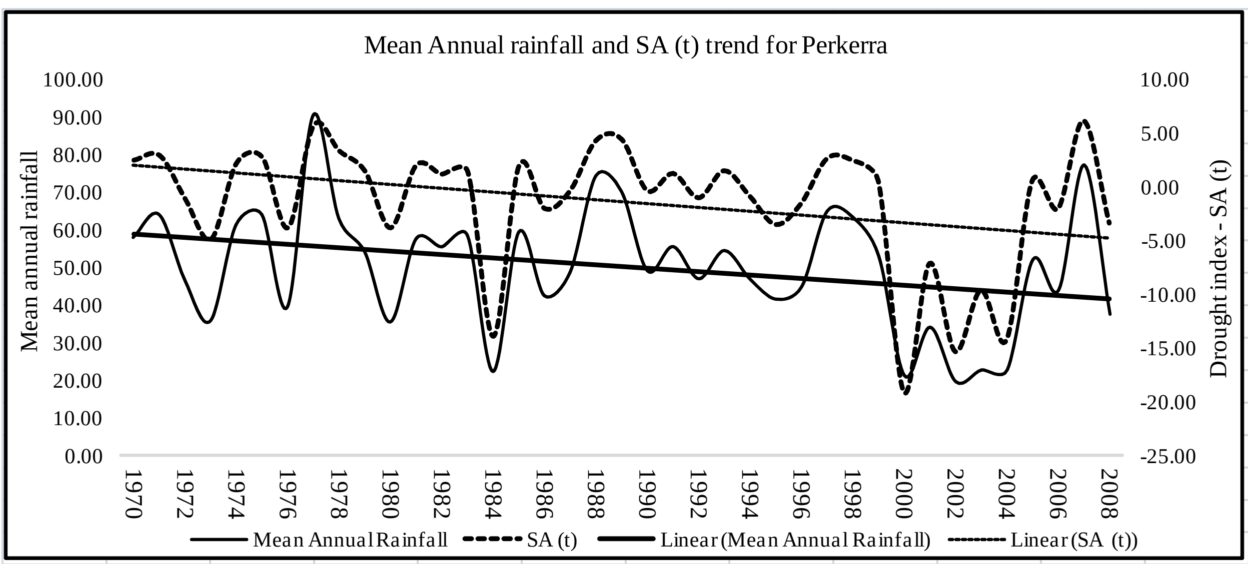


Figure 4.2c

Relationship between mean annual rainfall and annual drought indices for LM5 zone - Perkerra rainfall station

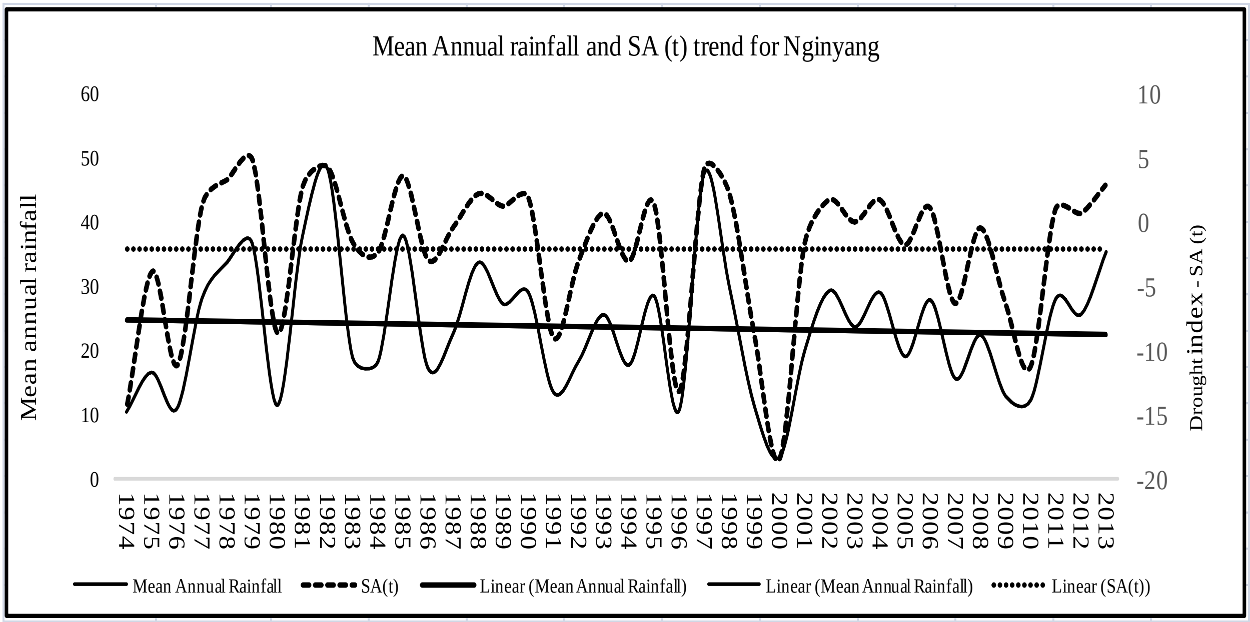


Figure 4.2d

Relationship between mean annual rainfall and annual drought indices for IL6 zone - Nginyang rainfall station

In the IL6 zone - Nginyang station - data on a time scale of 12-month (annual) reveal five catastrophic drought periods in the study area observed in 1974, 1976, 1996, 2000 and 2010 period (Figure 4.2b) with standard anomalies less than -0.9 (SA (t)< - 0.9) as a function of the time scales. The study observed noticeable severe drought events in 1980, 1999 and 1991 with standard anomalies between -0.9 and – 0.6 as a function of the time scales (Figure 4.2b). The drought events are likely related to shifts in warmer sea surface temperatures. Dai (2011) documented the 1970s and 1980s droughts in Western Africa – Sahel and attributed it to southward shift of the warmer sea surface temperatures in the Atlantic and warming in the Indian Ocean. Dutra *et al.* (2013) and Tierney *et al.* (2013) registered drought in the horn of Africa in 2010 while drought in Ethiopia and Somalia were attributed to Indian Ocean sea temperatures that have influence in the East African rainfall (Masih *et al.*, 2014; Dutra *et al.*, 2013; Tierney *et al.*, 2013).

The annual rainfall and the drought indices - SA(t) are negatively correlated (r = -0.9218, p<0.05) in LM5 zone - Perkerra rainfall station (Figure 4.2c). The plot depicts a negative correlation between the total recorded annual rainfall and the annual standardized drought anomaly indices SA(t) as illustrated in figure 4.2c. Similarly, correlation analysis results between the annual rainfall and the drought indices - SA (t) in Nginyang also posted a significant negative correlation ($r = -0.6879$, $p<0.05$) (Figure 4.2d). This result is significant in analysing effects of drought in livestock assets for it is an indication that severity of drought increases with decrease in rainfall amount. The strong negative correlation indicates that there exists a strong significant association between rainfall amount and drought events in the study. The results provides an option of using rainfall received to determine the corresponding effects of drought on livestock assets in the study area.

4.4.3 Estimation of Seasonal Drought Index

The seasonal drought index - SA(t) for the variation of rainfall in 1970 – 2008 periods for the two stations are plotted for the March-April-May (MAM) and October-November-December (OND) in figure 4.3a and 4.3c and over the period 1974 - 2013 in figure 4.3b and 4.3d.

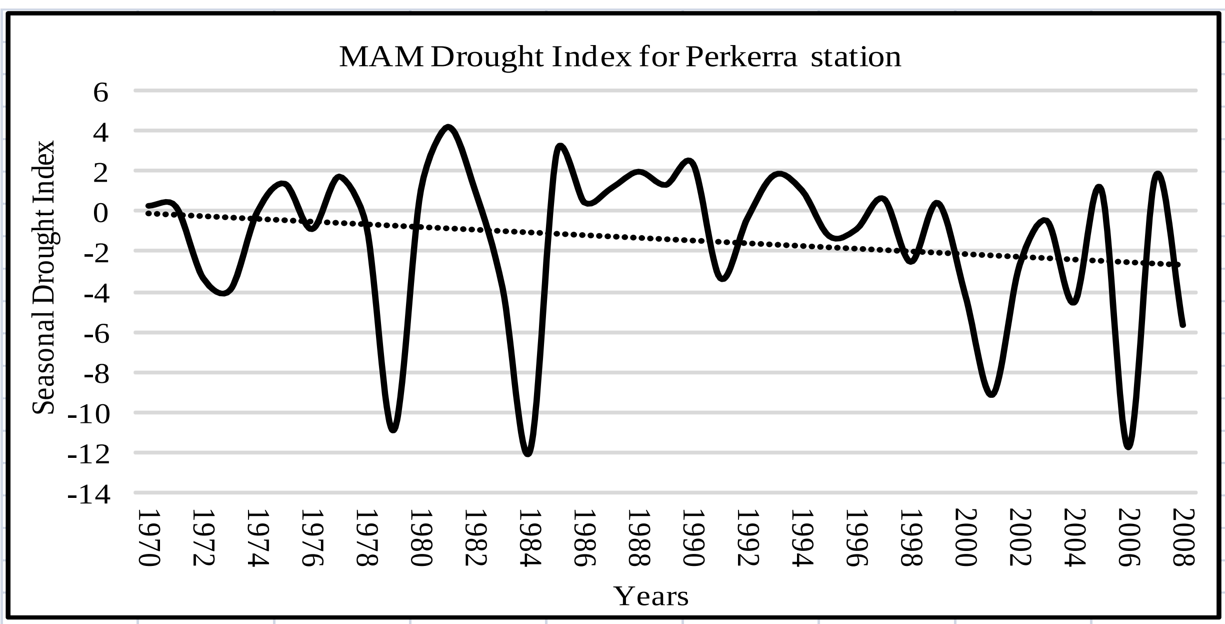


Figure 4.3a

March-April-May (MAM) drought index for LM5 zone - Perkerra rainfall station

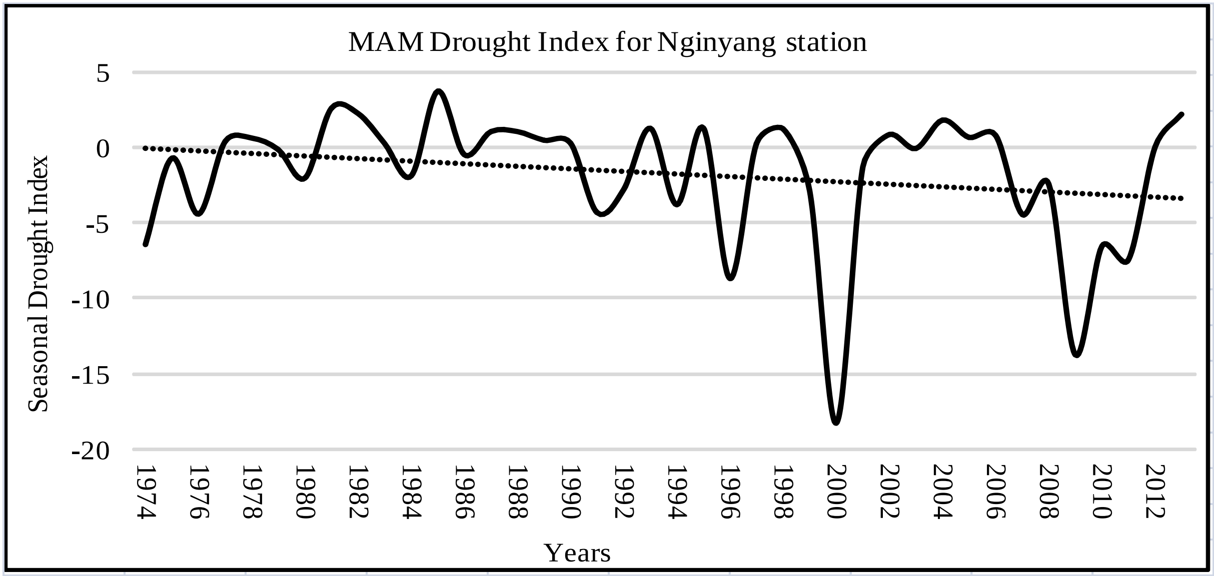


Figure 4.3b

March-April-May (MAM) drought index for IL6 zone - Nginyang rainfall station

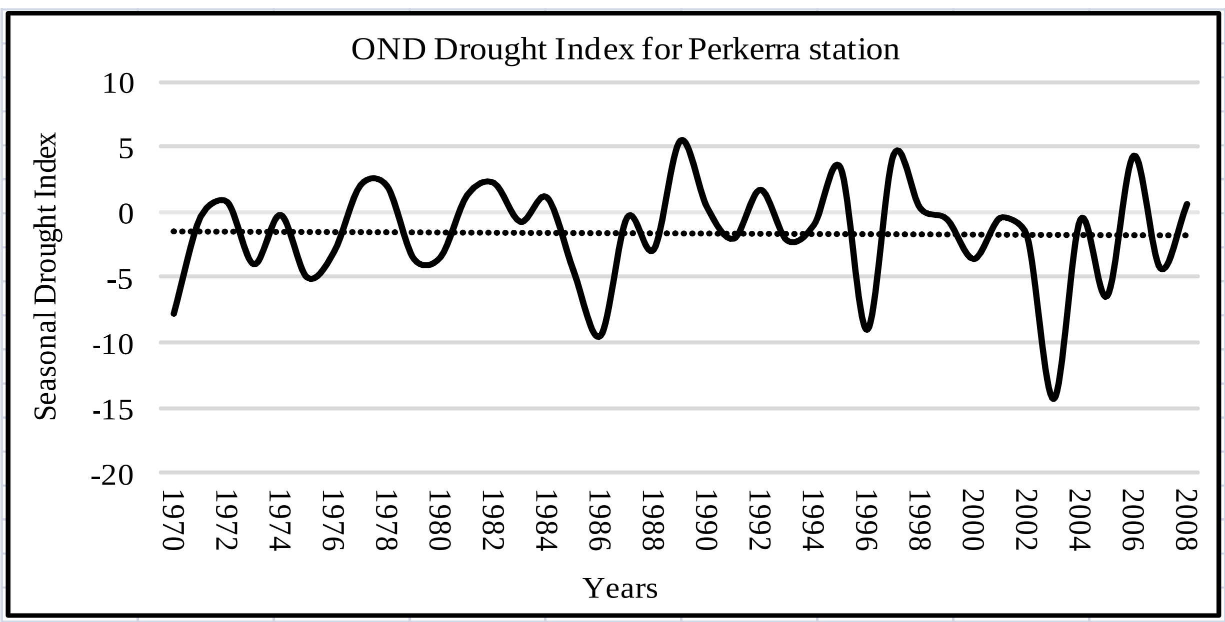


Figure 4.3c

Oct-Nov-Dec (OND) drought index for LM5 zone - Perkerra rainfall station

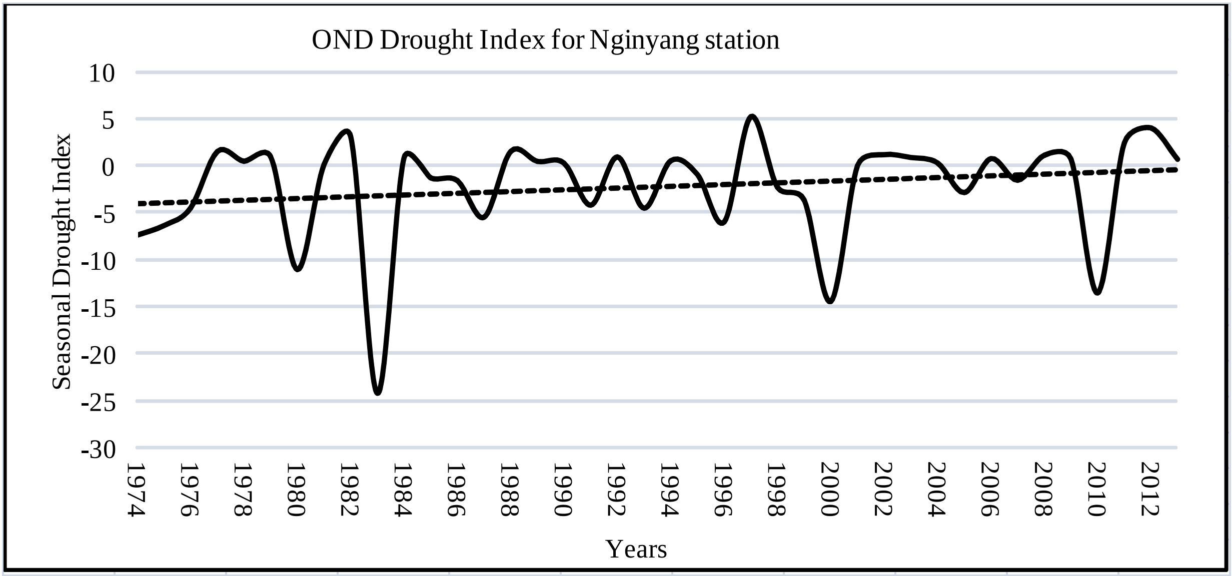


Figure 4.3d

Oct-Nov-Dec (OND) drought index for IL6 zone - Nginyang rainfall station

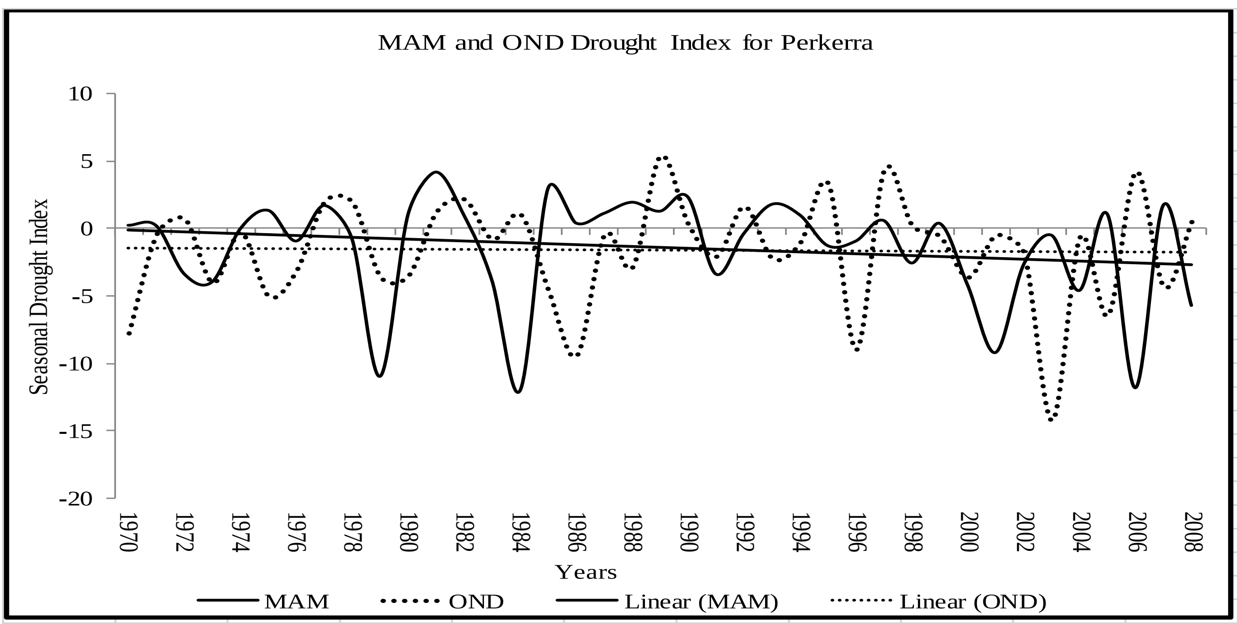


Figure 4.3e

March-April-May (MAM) and Oct-Nov-Dec (OND) drought index for LM5 zone – Perkerra rainfall station

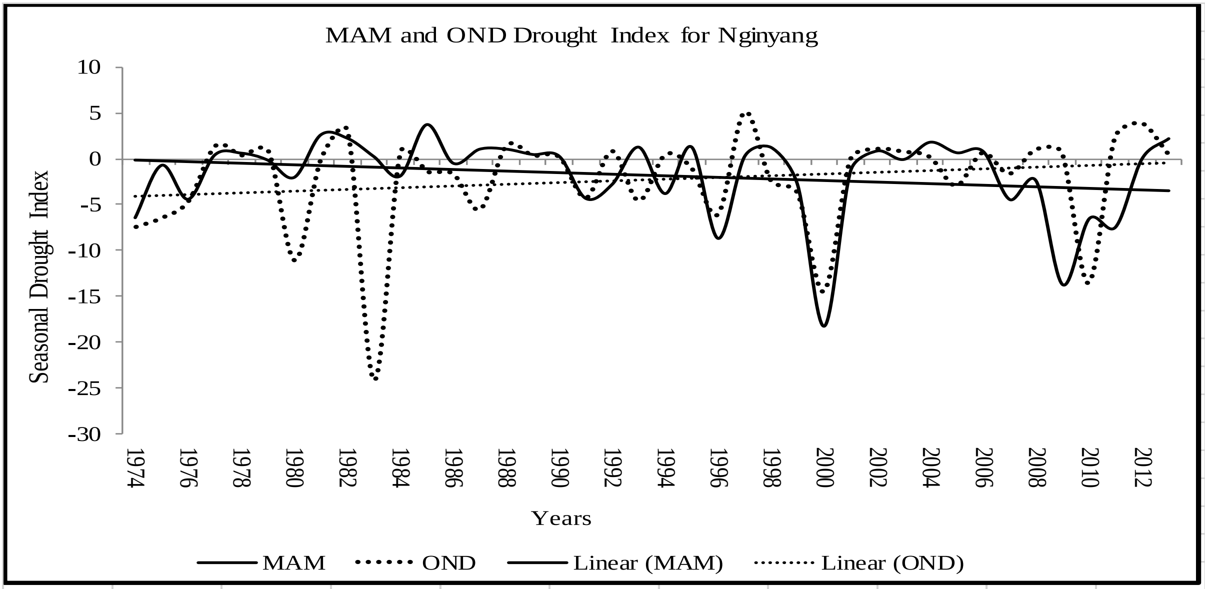


Figure 4.3f

March-April-May (MAM) and Oct-Nov-Dec (OND) drought index for IL6 zone – Nginyang rainfall station

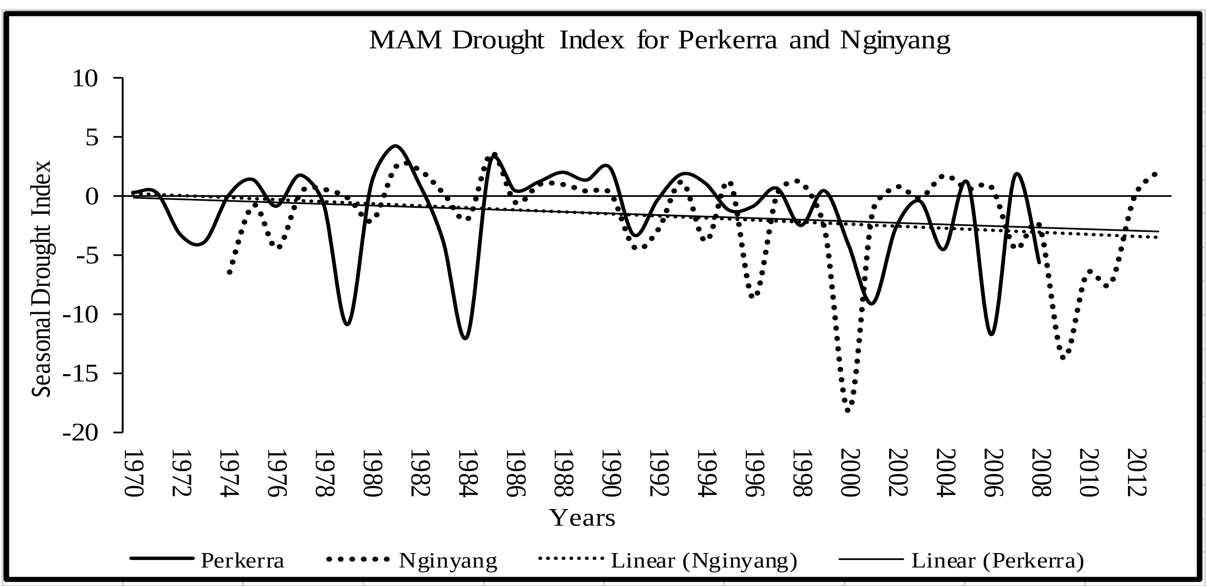


Figure 4.3g

March-April-May (MAM) drought index for LM5 zone – Perkerra rainfall station and IL6 zone – Nginyang rainfall station

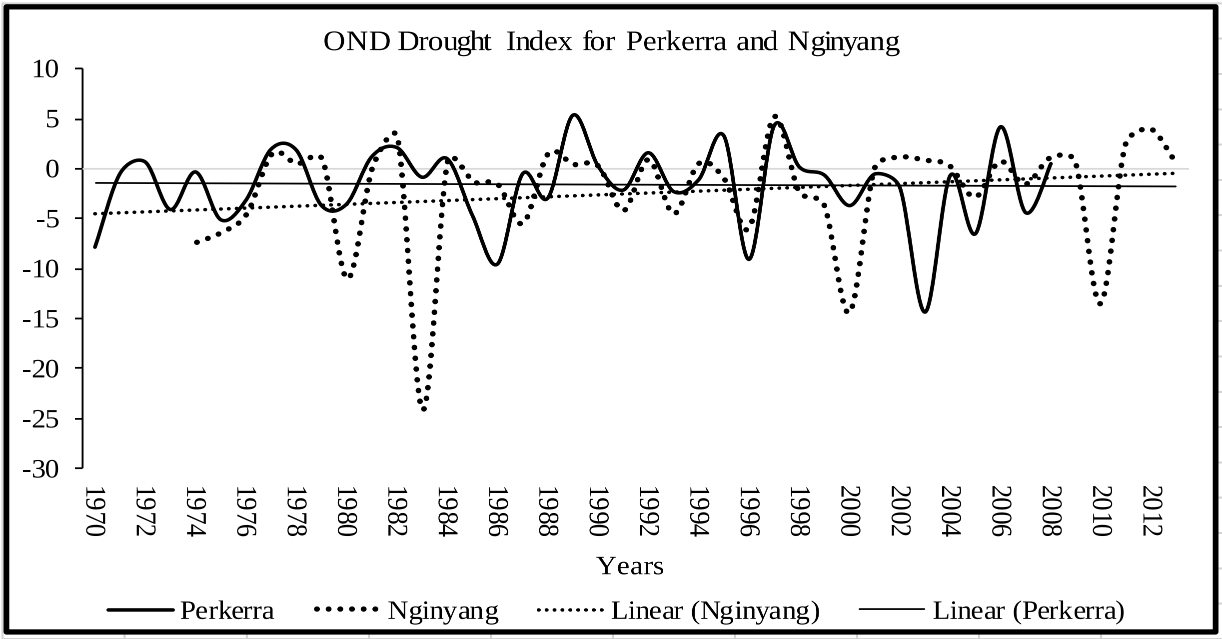


Figure 4.3h

Oct-Nov-Dec (OND) drought index for LM5 zone – Perkerra rainfall station and IL6 zone – Nginyang rainfall station

The MAM seasonal drought index plot for LM5 - Perkerra rainfall station - shows intermittent trend of drought events with peaks observed in 1979, 1983, 2000 and 2005 and a declining trend indicating drier conditions, which implies that the region is vulnerable to drought events (Figure 4.3a and 4.3e). The MAM in IL6 - Nginyang station - seasonal drought index plot shows fluctuating trend of drought events with drought peaks observed in the years 2000 and 2009 and others visible in the years 1974, 1996, 2010 and 2011. The long-term MAM seasonal trend for rainfall shows a declining trend, which is an indication of drier conditions over long time scale and implies vulnerability of the region to drought (Figure 4.3b). This corroborates with Masih *et al.* (2014) that significant increase in drought occurred in the African continent during the 1901-2011 period.

The OND seasonal drought index plot for LM5 zone - Perkerra station - shows few drought events with the major drought event peak being observed in the years 2003 (Figure 4.3c) and shorter peaks in the years 1985 and 1996. Compared to the MAM seasonal drought index plot, the OND season has fewer drought events for the 39-year period for Perkerra rainfall station

(Figure 4.3e). Noteworthy, from the OND seasonal drought index plot, the study deduced that the long-term OND seasonal trend for rainfall shows a constant trend of below mean rainfall for Perkerra rainfall station (Figure 4.3c). Figure 4.3e shows that the long-term trend for MAM in Perkerra is worsening through time as compared to the OND trend, which displays a relatively constant situation. This finding is a pointer to the fact that pastoralists can effectively utilised the opportunities that exist during the OND season which seems to be stable as compared to the MAM season (Figure 4.3e).

On the other hand, the OND seasonal drought index plot also shows a fluctuating trend of drought events in Nginyang with catastrophic drought events being observed in years 1980, 1983, 2000 and 2010 (Figure 4.3d). Severe drought peaks include year 1974 and 1996. Compared to the MAM seasonal drought index plot, the OND season seems to have more catastrophic drought events for Nginyang rainfall station (Figure 4.3f). However, from the OND seasonal drought index plot (Figure 4.3d) and the combined MAM and OND plot (Figure 4.3f), the study observed that the long-term OND seasonal drought trend shows a gentle upward trend, an indication that the conditions are improving. The trend indicate that in IL6 zone - Nginyang station - rainfall totals with time is likely to display an upward trend with decreasing drought severity for OND season.

Based on the trend (Figure 4.3f), pastoralists should be ready to face tough times during the MAM season of drought years, a period when disposing off of livestock may be considered timely during to worsening situation. Drought impacts negatively on pastoral livestock assets and food security and therefore requires an integrated approach with a shift from crisis management to risk management that includes use of early warning systems and seasonal climate forecasts (Tadesse *et al.*, 2008; Vicente-Serrano *et al.*, 2012; Masih *et al.*, 2014). Comparing the two regions of Perkerra LM5 and Nginyang IL6, the MAM seasonal trend shows declining trend (Figure 4.3g), an indication of drier conditions compared to OND seasonal trend that displays below mean rainfall (Figure 4.3h). More so, the plots show a likelihood of decreasing drought severity for the OND season for Nginyang and a relatively constant trend for Perkerra. Comparing the two study locations (Figure 4.3g and 4.3f), the study areas is becoming drier over time. The pastoralists should therefore invest in livestock types that are more resilient to dry conditions and where possible, diversify in both the livestock types and non-pastoral activities in order to cushion themselves against drought events. In confirmation of past drought situation in the study area, Mr Stanley Kibiwot of NDMA confirms said;

"Baringo County over the years has experienced drought events adversely affecting human lives and livestock assets. The drought events have become more severe calling for timely dissemination of early warnings and planning".

4.4.4 Household Perception of Rainfall Trends

An overwhelming majority (95%) of the households had the perceptions that rainfall had been decreasing in the last 5 years in the study area. This perception is consistent with the observed annual rainfall data for the period 1970 to 2013 in IL6 and LM5 and with the UNDP's climate change profile for Kenyan ASALs for the period since 1960 (McSweeney *et al.*, 2010). It is also corroborating with 26.2% reduction in rainfall observed for 1975-2005 period in North Eastern ASALs (Demombynes & Kiringai, 2011). This demonstrates exposure to extreme drought events for which Vogel *et al.* (2010) advocates learning from past drought events to empower households with knowledge of drought events and adaptation responses in the past. This learning can facilitate building resilience to reduce vulnerability to droughts.

When asked about the overall trend of rainfall distribution in the study area for the past 5 years, majority (82%) of the respondents reported a decreasing spatial distribution of MAM and OND rainfall with the remainder (17%) reporting observing no marked change in the trend. Majority (81-90%) of the respondents substantiated that the number of rain days in each year were decreasing and that frequency of annual drought had increased over the years. The perceptions about increasing severity of drought over the years concurs with empirical evidences from Masih *et al.* (2014) who recorded statistical increase in drought on the African continent during the period 1901-2011. The study concluded that drought have become more frequent, intense and widespread in the last 50 years and that Africa will likely continue experiencing severe and prolonged drought events. The effects will be detrimental to the livelihoods of the pastoral community if progress in drought risk management remains slow as the threats to pasture and water sources grows in magnitude.

4.5 Effects of Drought Events on Livestock Assets

4.5.1 Observed Effects of Drought Events on Livestock Assets

Figure 4.4 and 4.5 shows a general increase in the total livestock owned (total number and TLU) between May and September during the year 2015. This is a pattern partly attributable to seasonal calving corresponding to seasons of improved pastures and water resources in the area. A decline in the number of livestock owned was observed in September to October 2015 correspond to a period of decline in rainfall amount for which pastoralists response is trekking of animals over longer grazing distance in search of pasture and water (NDMA, 2015). The study by Nkedianye *et al*. (2011) on livestock mortality rates following the 2005 drought in four areas in Maasailand established that mobility resulted from worsened shortage of forage and water due to high stocking densities. In concurrence with the current study, McCabe *et al*. (1987) established that drought initiated mobility and tribal raiding among the Turkana and Pokot communities in a pursuit to replace livestock lost through drought.

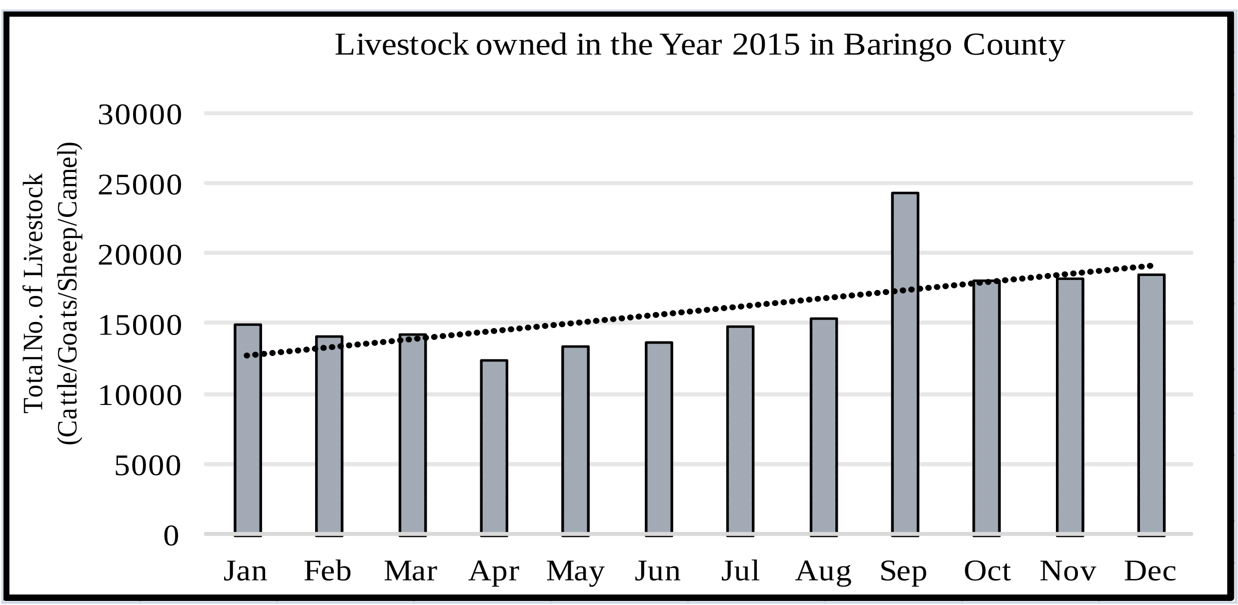


Figure 4.4

Total number of livestock owned in 2015 in Baringo County

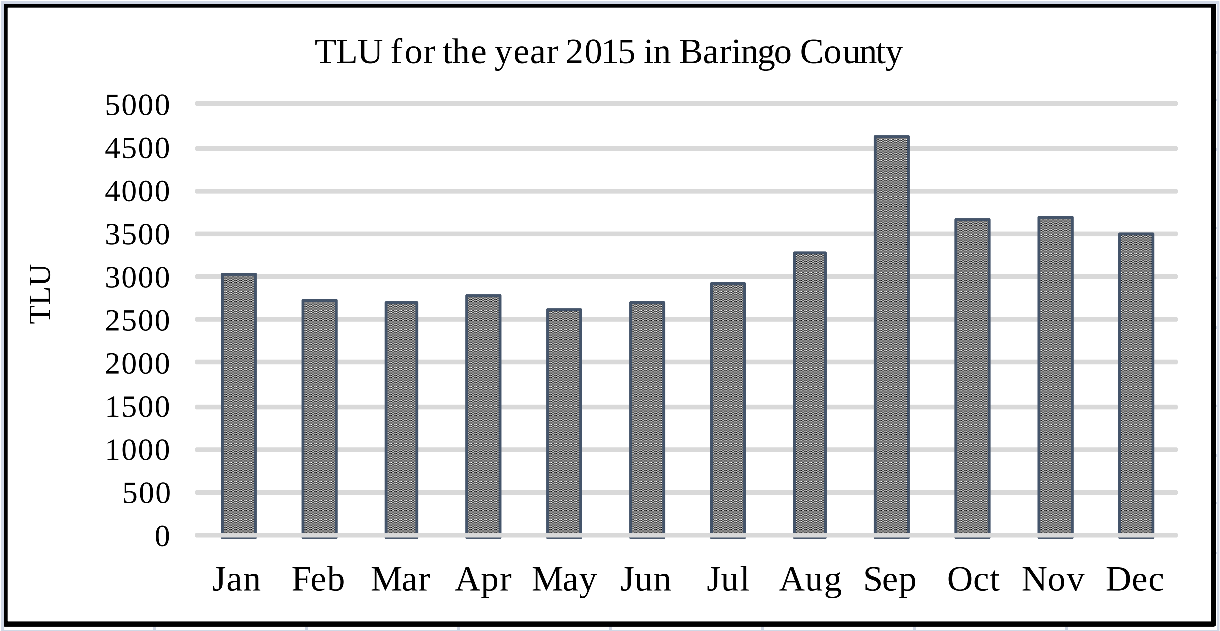


Figure 4.5

Livestock owned in terms of Tropical Livestock Unit (TLU) in Baringo County

The total livestock ownership seasonally fluctuated during the year, indicating disrupted livelihood base (Figure 4.5). Herd size is a measure of wealth and status in a pastoral community and hence pastoralists want to accumulate and will be reluctant to dispose animals as an adaptation strategy (Borgerhoff *et al.*, 2010). The numbers ensure insurance against drought (Morton, 2007; McPeak, 2005) with which to rebuild the stock after droughts (Kaimba *et al.*, 2011). Keeping of goats is a diversification strategy to go through drought periods (Figure 4.6. 4.7, 4.8 and 4.9) because they can easily be liquated for cash income to meet livelihood needs of the households (NDMA, 2011; 2012; 2013; 2014; 2015).

Silanikove (2000) established that goats are more adaptive to harsh conditions because of low body mass metabolic requirements that minimise their maintenance and water requirements. In addition, goats browse more for their dietary needs. These attributes allows goat to survive prolonged drought situations as compared to the grazers (Silanikove, 2000). It is important to note that though January was a dry month, the number of cattle was relatively high. This is attributable to progressive onset of dry conditions and so is the progressive loss of pasture and water. Howitt *et al*. (2015) in an economic analysis of the 2015 drought for California agriculture reached this conclusion from observation that continued drought caused further deterioration of pasture conditions and decline in the cattle herds.

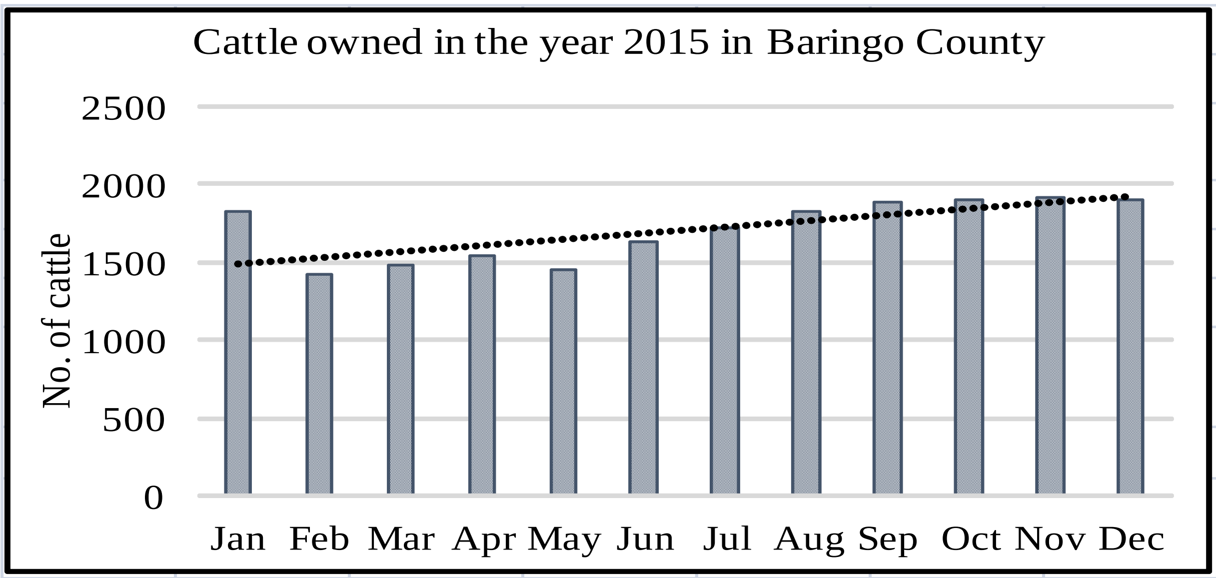


Figure 4.6

Number of cattle owned in 2015 in Baringo County

The upsurge observed in the number of goats owned (Figure 4.7) in September could be have resulted from breeding season in June and July 2015 corresponding to when pastures, browses and water are in plenty as previously observed by Kgosikoma (2006). The increase in number of goats during the breeding season also serves as a safety net during times of drought. Pereira & Amorim (2010) in pursuit to trace the origin and spread of goat pastoralism established that the successful geographical diffusion and exponential growth of goat populations around the world demonstrate remarkable adaptability of the ruminant species to extreme climates and difficult terrains. Maina (2014) more so indicated that most pastoralists in Kajiado Central kept a mixed herd of large and small ruminants as an adaptation strategy in times of drought which directly influenced the increase in number of goats during the breeding season.

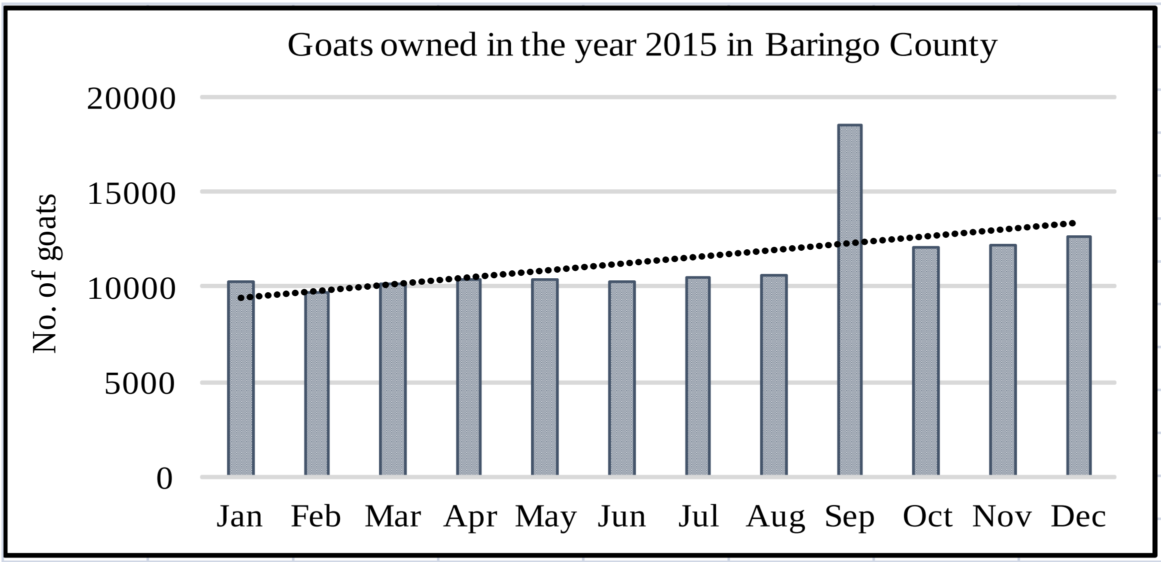


Figure 4.7

Number of goats owned in 2015 in Baringo County

Figure 4.8 displays a sharp decline in sheep owned in May and June is attributable to a response strategy to drought events as they are easy to dispose of and replenish during times of drought (NDMA 2015; 2016). The number of sheep compared to goats is relatively low because drought severely affects them. The present study established that the number of sheep owned varies with the quality of grazing and feed availability in harsh environments, a finding that concurs with Devendra (2005). According to the present study, respondents indicated that most pastoralists will dispose of sheep when there are signs of droughts or disease outbreak. NDMA (2015) has also associated decline in population of sheep with upsurge of diseases related to new rains.

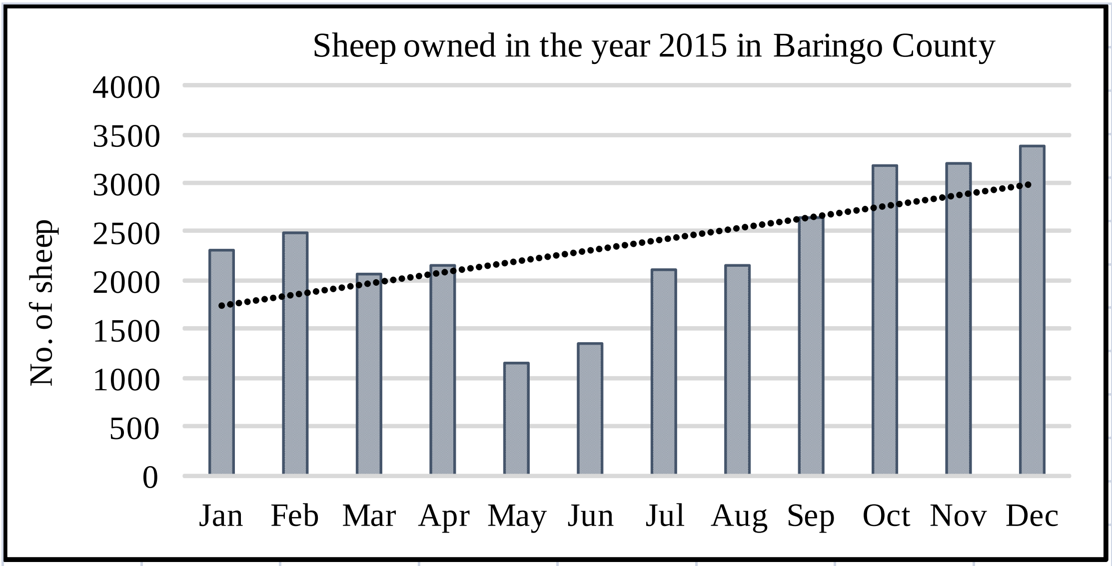


Figure 4.8

Number of sheep owned in 2015 in Baringo County

Camel ownership as well displayed seasonal fluctuations (Figure 4.9) with a mean of 622 camels in 2015 though ALRMP (2005-2011) and NDMA (2011-2015) reports stable herd sizes. ALRMP (2005-2011) and NDMA (2011-2015) found out that the number of camels owned rarely change because they are less vulnerable to drought events and more so pastoralists rarely dispose them of as a drought response strategy for commercial purposes. Livestock rustling and disease affects camel stock the most. The significant drop in number of camels owned in October 2015 reflects cattle rustling in the period concurring with Kaimba *et al*. (2011), study that assessed the effects of cattle rustling on herd size among pastoralists in Baringo District. Results indicated that livestock rustling is a rampant practice among the pastoralist communities in Kenya and affects the herd size. The authors established that pastoralists at times engage in livestock rustling to replace livestock lost during drought or diseases epidemics.

Mr Gedion Ndole, Livestock extension officer in the department of livestock production in Baringo County indicated that;

"Mobility during times of drought leads to resource conflicts". This affects all livestock types including camels that are relatively drought resistant. Mr Stanley Kibiwot, NDMA personnel, Marigat Office said;

"It is during the times of drought that communities engage in cattle rustling to replace the lost herd".

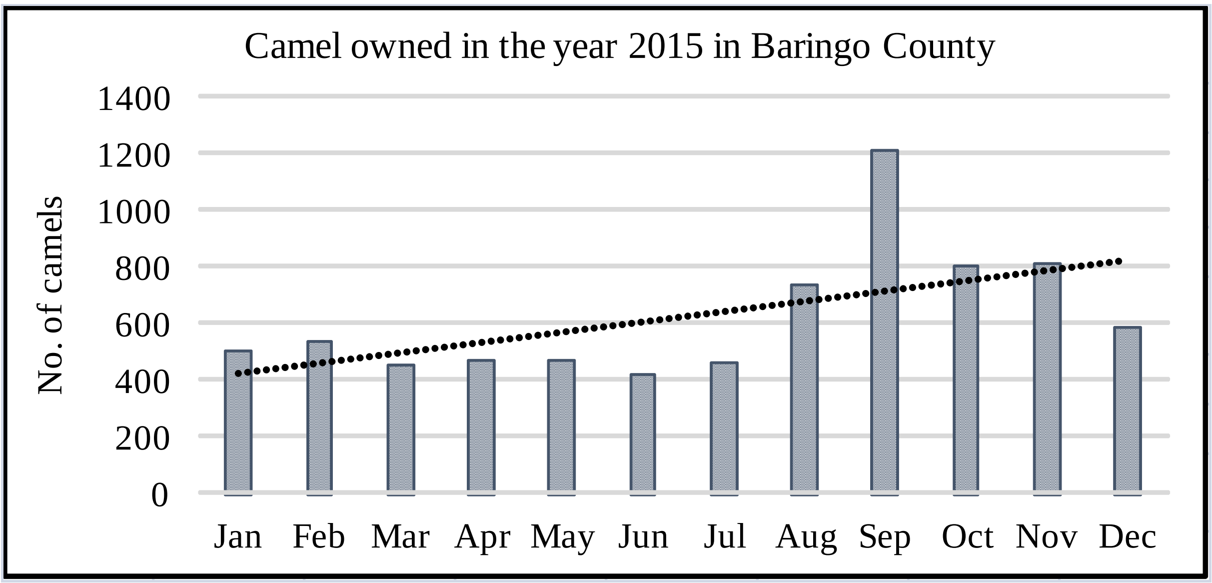


Figure 4.9

Number of camels owned in 2015 in Baringo County

Drought is the most pervasive hazard in the ASALs accounting for the loss of livestock assets (Mude *et al.*, 2009a; Mbogo *et al.*, 2014; Kgosikoma, 2006). Livestock deaths generally corresponded to periods of decline in rainfall (Figure 4.10 and 4.11), and were corroborated with resilience intervention assessment reports (NDMA, 2014; 2015; Kipterer & Ndegwa, 2014). Cattle deaths were highest in March 2015, coinciding with the dry spells in January and part of February and in April and May in the study area. Deaths were relatively fewer in December, which corresponds to improved rainfall in September and October when water and pastures availability improves.

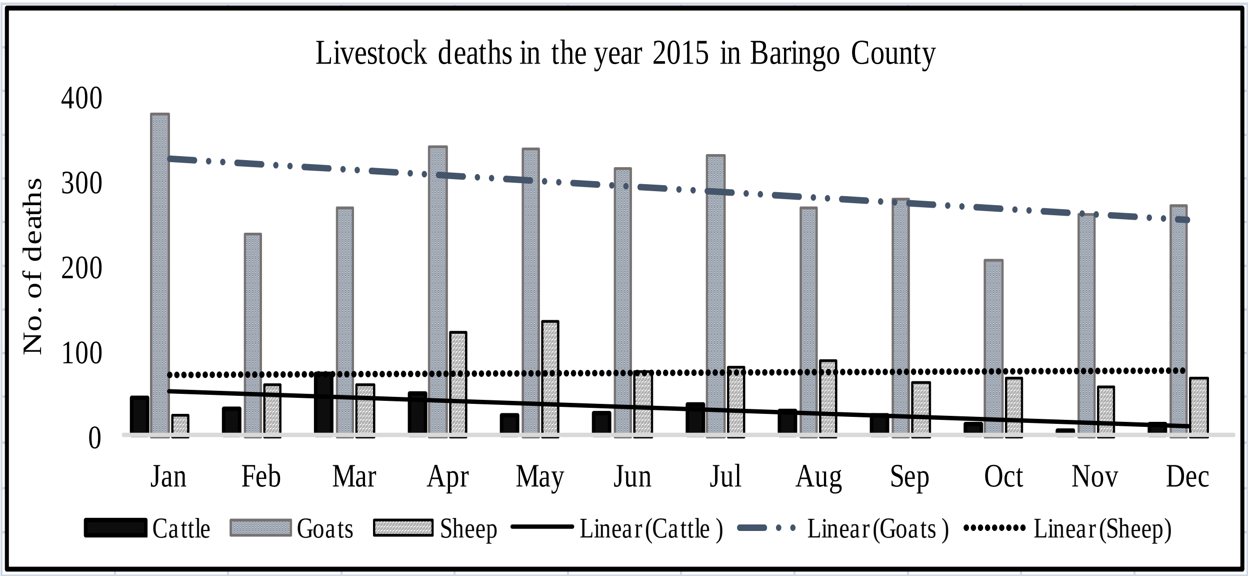


Figure 4.10

Livestock deaths in 2015 in Baringo County

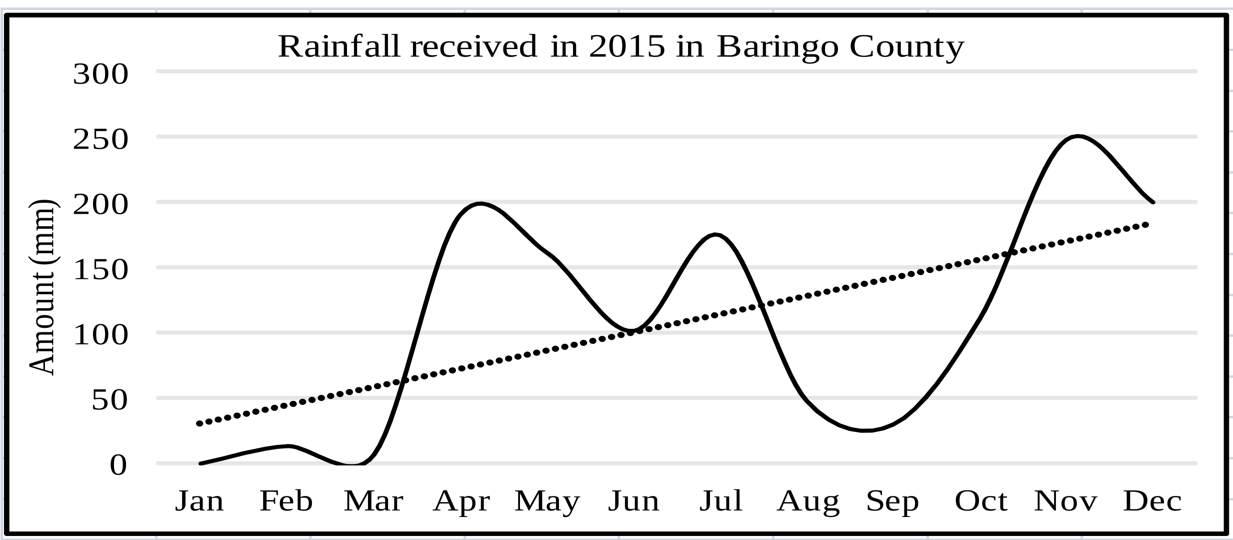


Figure 4.11

Rainfall trend in 2015 in Baringo County

Figures 4.12, 4.13 and 4.14 illustrates the 2014 and 2015 annual and long-term average livestock prices of cattle, goats and sheep in the study area. The downward trend in the prices on all species of livestock between January and May corresponds to dry spell experienced in

January and February 2014 and 2015 (NDMA, 2015; Kipketer& Ndegwa, 2015). During the dry spell, deterioration of livestock body condition lowers their market value (Leister *et al.*, 2013; NDMA, 2015) for which Lewa (2015) recommends contingency plans such as feed reserves, efficient marketing and meat processing facilities and access to productive pastures, to facilitate offtakes when market prices are attractive.

The seasonality of cattle price in contrast to that of small stock (goats and sheep) points to seasonal demands for small stock in December for religious festivities and improved pasture, browsing conditions and water availability (NDMA 2014; 2015). Distress sales of livestock has been observed to rise during times of drought in Ethiopia region of Wollo (Spiegel *et al.*, 2004) when prices are low hence financial loss. Huho & Kosonei (2014) made similar observations in the Laikipia North and Bunyala in Kenya where cattle prices dropped from KES 11,000 (110 USD) during the 1992 mild drought to KES 6,000 (60 USD) during the 1996 extreme drought while sheep and goats prices dropped from KES 1,425 (140 USD) to KES 600 (60 USD) over the same period.

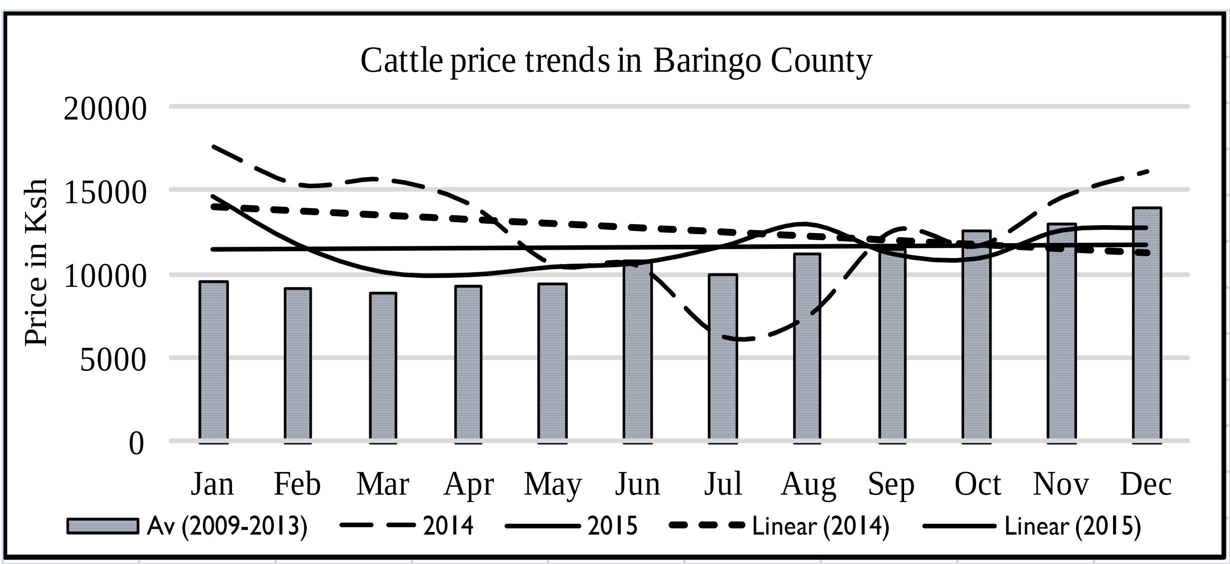


Figure 4.12

Cattle prices in Baringo County

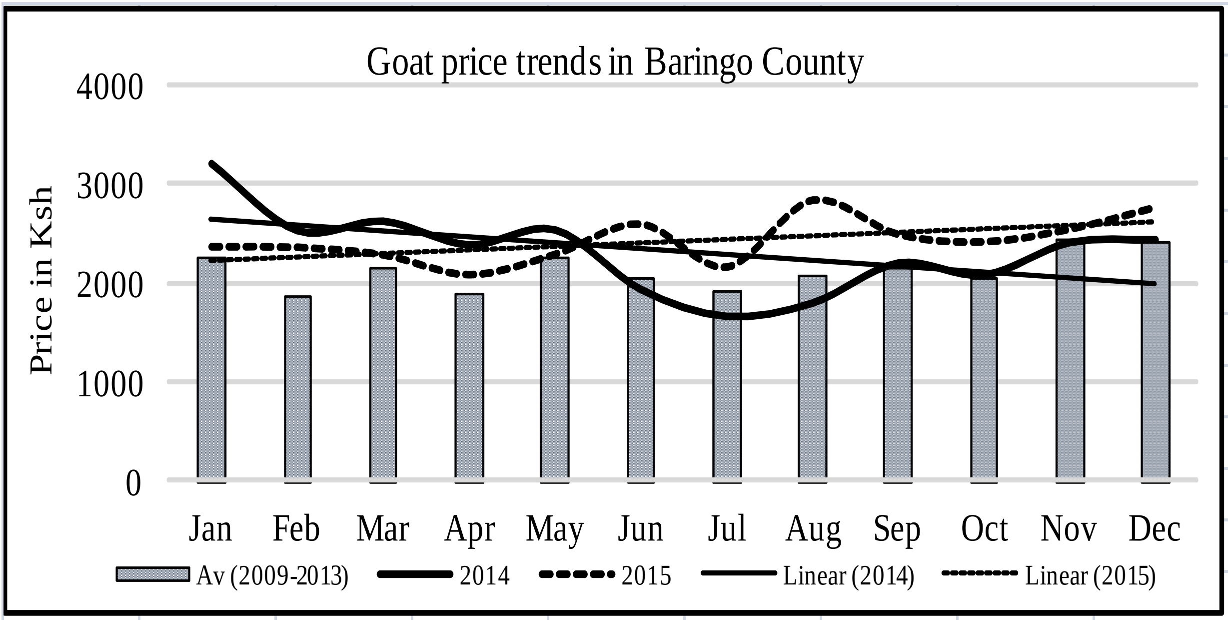


Figure 4.13

Goat prices in Baringo County

Figure 4.14 shows a plot of sheep price across from January – December. The price fluctuations across the period correspond to pasture and water seasonality. Incentives that increase the exchange value of livestock and livestock products may be the options to trigger voluntary sales of livestock by pastoralist (Kerven, 2016).

In an interview with Mr Gedion Ndole, Livestock extension officer in the department of livestock production in Baringo County, the officer confirmed that drought events affect various livestock assets and prices. By using his own words, Mr Ndole said:

> *"Pastoralists will always use sale of goats and sheep to buy food items but during prolonged dry period and insecurity, the prices are usually undermined by distress sales".*

This statement supports the present study findings that prices of various livestock types fluctuates with rainfall amount, pasture and water availability in the study area. Mr Ndole further said;

"Drought normally affects livestock body conditions leading to low prices. This negatively affects the purchasing power of the pastoralists and ability to restock after drought".

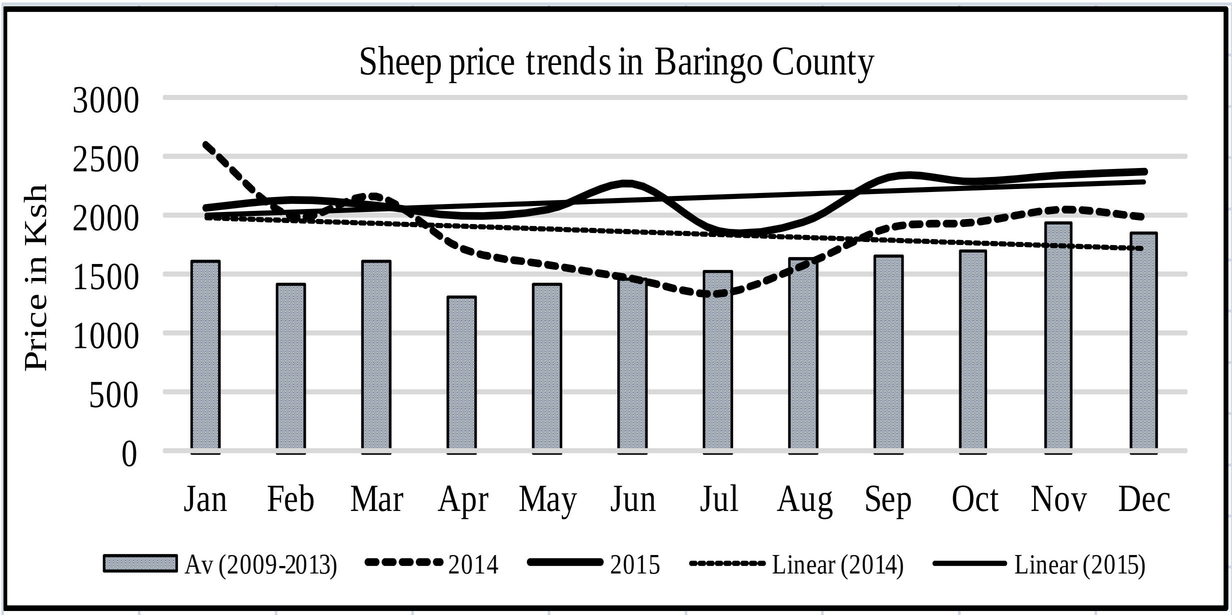


Figure 4.14

Sheep prices in Baringo County

Dahl & Hjort (1976) considers milk as the most important source of food for the pastoral communities. Different anthropological studies indicate various amounts of milk available for human consumption that should be the excess milk over and above the needs of a calf (Bremaud & Pagot, 1962; Evans-Pritchard, 1940; Joshi *et al.*, 1957). Figure 4.15 shows that milk production between January 2014 and May 2014 was seasonally fluctuating with peaks in June, July and September 2013 attributed to seasonal scarcity of pasture and browse during dry spells. Peak milk production was in the month of August to December 2014, explained by more rainfall supporting growth of pasture and browse.

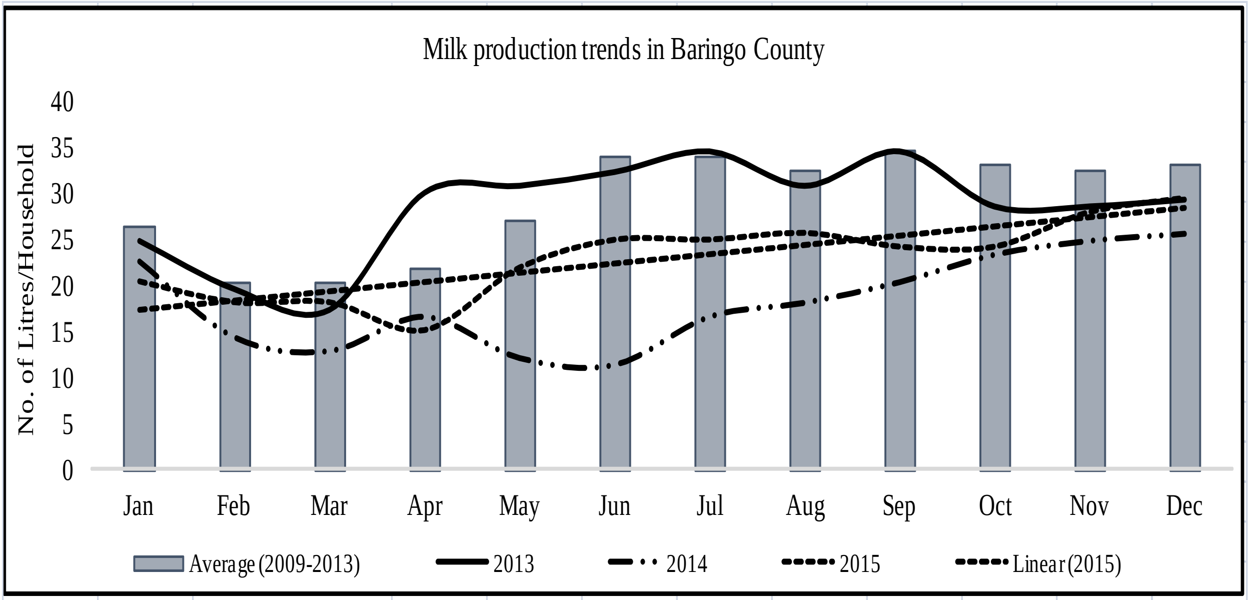


Figure 4.15

Milk production trends in Baringo County

On the other hand, milk production generally declined in January 2015, attributable to low rainfall to support growth of pastures and browses. However, an increase in milk production was observed from a monthly average of 18 litres per household in 2014 to 22.5 litres per households in 2015 with highest monthly of 28.5 litres per household realised in 2013. The lowest milk production in 2015 was in April, corresponding to period of below normal rainfall received in March 2015.

Variations in rainfall amounts result in variable water, vegetation, pasture, livestock health and milk production. This is a phenomenon corroborating the observation that Howitt *et al.* (2015) made in California in the year 2014. There was a drastic drop in milk production following drought. This further concurs with the study of Sweet in North Arabia cited in Dahl & Hjort (1976) that "cows only give milk during the moist season that normally lasts for around five months". Meyn in *Beef production in East Africa* indicates that zebu cows on daily basis will yield approximately 2-5 litres (60-150 litres per month) of milk during the rains and only 1-2 litres (30-60 litres per month) of milk or completely dry in the dry season (as cited in Dahl & Hjort, 1976). A finding that supports the present study that milk production is directly influenced by rainfall amount and drought events. The study indicates that the average litres expected on monthly basis is below the amount received in the study area, a finding that the present study linked to dry conditions and prevalent drought (Dahl & Hjort, 1976).

The regression results in Table 4.6 define relationships between animal dynamic variables with rainfall for the year 2015. A unit increase in the amount of rainfall results in 0.02 litres increase in milk production. The month with lowest milk production in the year 2015 was April. The sheep owned, cattle owned, sheep prices and cattle were positively associated with the amount of rainfall received. The results show decline in rainfall is followed with reduced livestock performance, which concurs with Nkomo *et al.* (2006) and Kirimi (2011) and is a result of scarcity of water and pastures when rainfall declines. However, the number of goats and camels owned increased with decline in rainfall, which can be attributed to less vulnerability of goats and camels to drought events as observed by Mr Gedion Ndole, Livestock extension officer in the Department of Livestock Production in Baringo County who expressed an opinion that;

"The amount of milk production decreased during the dry season due shortage of pasture and water in Baringo".

Table 4.6

Regression models between various livestock assets and rainfall

Livestock asset	Coefficients		F-value	p-value	R^2
	Constant	Rainfall			
TLU	16043.27	-1.115	0.01	.928	.0009
Cattle owned	1656.28	0.428	0.38	.552	.0365
Goats owned	11505.20	-0.761	0.01	.933	.0008
Sheep owned	2177.89	1.665	0.46	.514	.0438
Camel owned	649.40	-0.257	0.09	.768	.0091
Cattle price	11882.94	-2.285	0.21	.658	.0204
Goat price	2440.10	-0.116	0.02	.891	.0020
Sheep price	2112.05	0.324	0.28	.611	.0268
Milk	20.60	0.020	2.03	.185	.1687

Source: Field Data, 2016

4.5.2 Perceived Effects of Drought on Livestock Assets

From the household survey data (Figure 4.16), respondents associated mortality with drought events (77.1%), diseases (16.1%), poisonous plants (5.5%) and rustling (1%). It can be inferred that drought accounts for the largest proportion of mortalities, from farmers' perception, corresponds to 2008 to 2009 drought events (Huho & Mugalavai, 2010) when Baringo County experienced significant scarcity of pasture, water sources and rise in livestock in starvation or death. The main sources of water for the livestock in the ASALs are open wells and water pans but these often dry up during drought as observed during 2005-2006 droughts when on average a family lost 53.8% of their cattle, 56.9% of the sheep/goats and 65% of the donkeys (Juma, 2009). A large loss of livestock of this magnitude disrupts the livelihoods built on livestock assets among the pastoral households.

Disease was the second most important cause of livestock losses (16.1%), of which contagious caprine pleura-pneumonia, Foot and Mouth, Trypanosomiasis and Diarrhoea were the most common in the study area. Increased incidences of these diseases were associated with herd mobility in search for pasture and water during drought events. Disease outbreaks cause loss of livestock assets and disrupt livelihoods by restricting market access during disease presence, drop in productivity and disrupt market prices. Under such conditions, local breeds, though low yielding, are better adaptable to drought events. Nkedianye *et al.* (2011) in assessing the impact of the 2005-2006 drought on livestock mortality in Maasai-land established that high yielding cattle and sheep are less tolerant to droughts, a finding that concurs with the results of the present study.

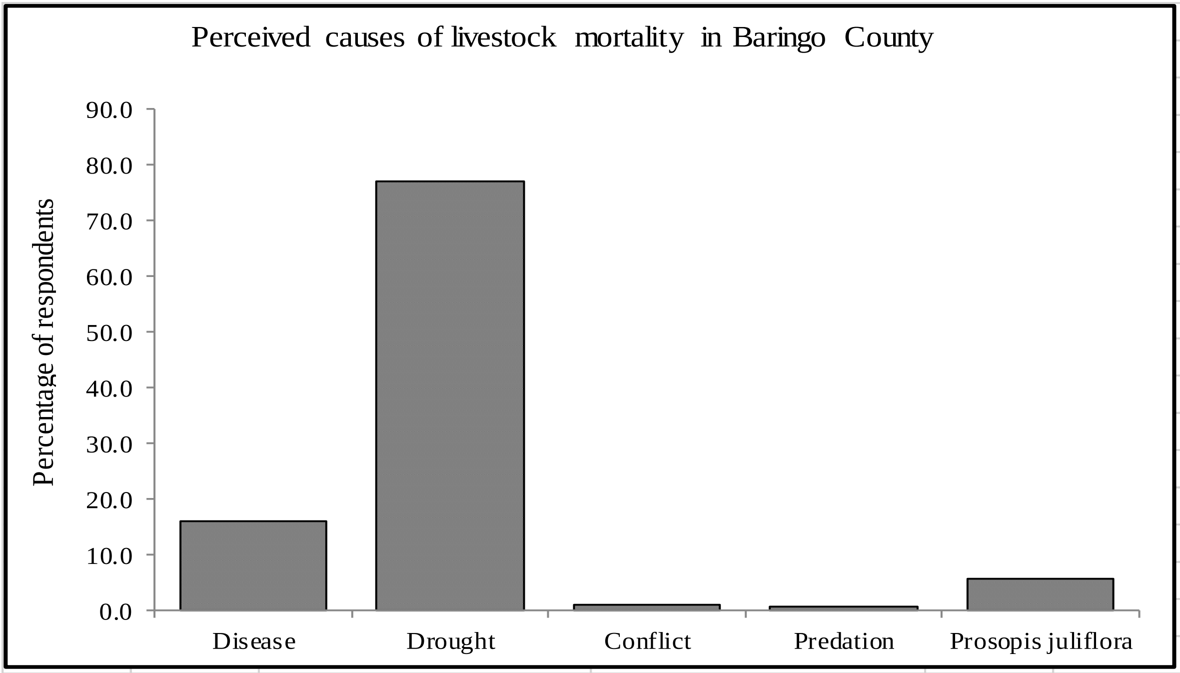
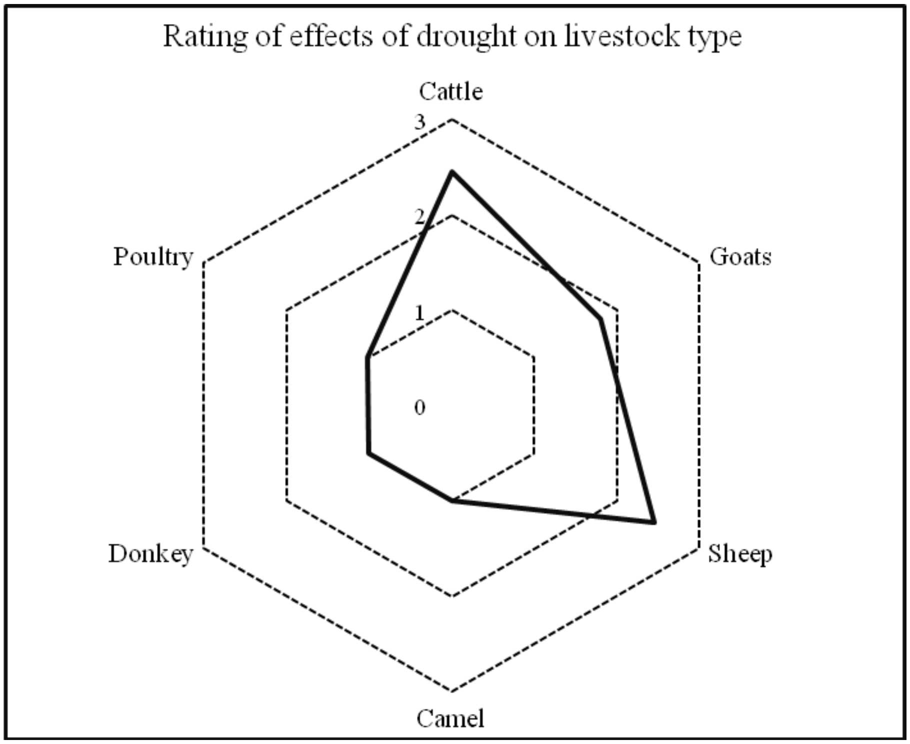


Figure 4.16

Causes of livestock mortality in Baringo County

From mean rankings (Figure 4.17), pastoralist considered drought effects most severe in cattle and sheep relative to other livestock with camels and donkey considered the most resilient. It was their perception that cattle and sheep are the most hit during drought, but they considered goats, camel, poultry and donkey as least affected. This finding concurs with NDMA (2014; 2015) which established that goats, camel and donkeys are more resilient to drought events compared to sheep and cattle.



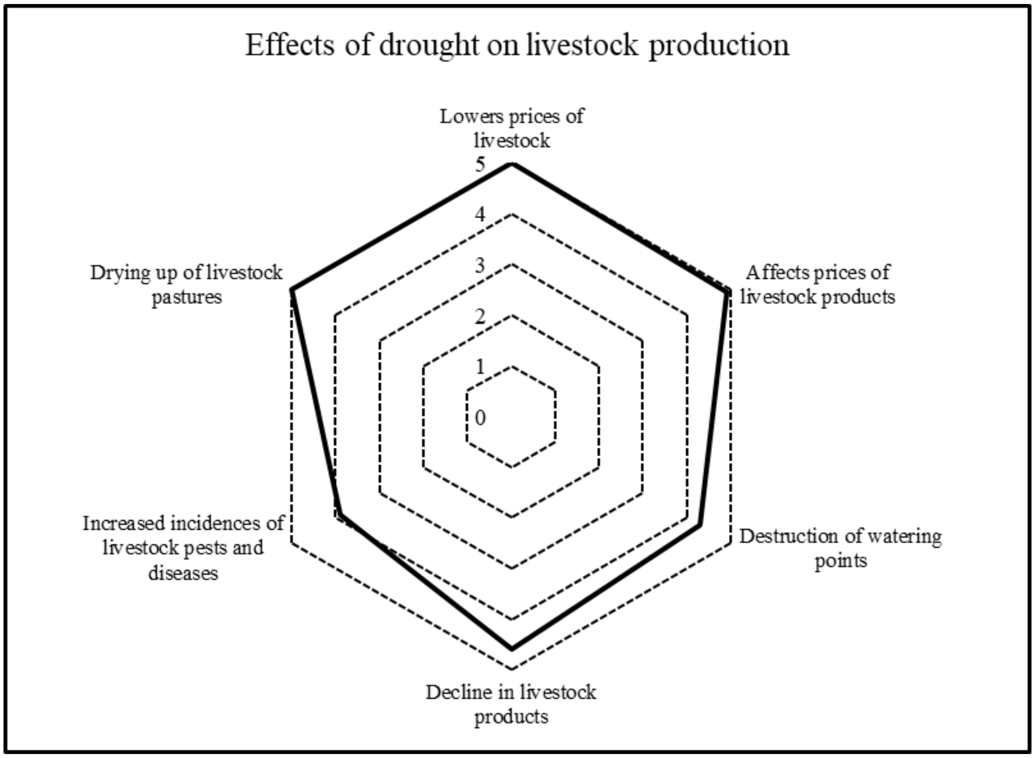
Scale: 3 – Very severe; 2 – Severe; 1 – Not severe

Figure 4.17

Rating of the effects of drought on type of livestock with regard deaths in Baringo County

The study links drought effects on livestock to scarcity of pastures and water (Figure 4.18). The response of most pastoral groups in the study area is to move herds elsewhere in a traditional migratory pattern, but this strategy fails to secure livestock assets (Kirimi, 2011; Nkomo *et al.*, 2006). In addition to losses from disease related deaths or rustling, market value drops drastically as well during drought because of poor body condition or disparate sales to escape droughts as observed by Spiegel *et al.* (2004) in Ethiopia region of Wollo. Low prices obtained during distress sales result in financial losses as observed by Huho & Kosonei (2014) in the Laikipia North and Bunyala in Kenya where cattle prices dropped during extreme drought.

However, Demombynes & Kiringai (2011) reported rise in prices of livestock products in Wajir and Marsabit regions in Kenya during drought events. In contrast, Lin *et al.* (2013) did not observe adverse impact of drought on the market prices of the livestock and other agricultural products in China, mainly because pastoralists supply the products to industries, which enter contract for constant prices in all seasons.



Scale: 5 – Strongly agree, 4 – Agree, 3 – Undecided, 2 – Disagree, 1 – Strongly disagree

Figure 4.18

Effects of drought events on livestock in Baringo County

From the study findings, the observed effects of drought concur with the households perceived effects of drought on livestock assets. Both data sets indicated that drought impact directly on pasture and water availability, which negatively affects milk production and livestock prices.

4.6 The Effectiveness and Usefulness of Seasonal Climate Forecasts in Predicting Observed Drought Events

The effectiveness and usefulness of seasonal climate forecast in predicting the observed drought events are computed from Tables 3.2 and 3.3 for sensitivity and positive predictive value. The effectiveness was 85.71% and 80% of the times for MAM and OND seasons respectively, meaning that failure rate was 14% of the times of the cases for MAM and 20% for OND seasons). The positive predictive value was 0.75 and 0.57 for MAM and OND seasons respectively, an indication that the relayed seasonal forecasts were 75% and 57% of the times useful in giving early warning about the observed drought events for MAM and OND seasons.

The high effectiveness and positive predictive values obtained demonstrates high degree of validity of seasonal climate forecast for early warning about drought events. Therefore, gives confidence in the use of climate forecast information to inform planned adaptation. However, in contrast, Hayman *et al.* (2007) found that seasonal climate forecasts failed to predict drought events in most of the times in Australia. It is important to note that pastoralists and other ASAL areas are interested in short term climate predictions to help them plan and reduce vulnerability to drought events.

In the sample households, about a third (33.03%) had received climate forecast information for monthly (46.6%), weekly (4.1%) and seasonal forecasts (49.3%), which shows that pastoral households more frequently received seasonal forecasts and monthly climate forecasts. Preference of the pastoralists was higher for seasonal climate forecast because pastoralists perceive that these are more reliable and relayed early enough to enable them plan for implementation of adaptation actions (Figure 4.19). The low percentage of households who received climate forecast information is a strong indication that majority of respondents have no access to scientific climate forecasts and therefore do not factor it in decision-making. This calls for intervention to improve dissemination of climate forecast information among the pastoral community, an aspect that the current study addressed through assessment of barriers and enabling conditions to dissemination, access and uptake of seasonal forecast information.

The respondents indicated that the information on seasonal forecast received was on rainfall and temperature for the coming seasons, often communicated in the native language and so pastoralists can understand the messages relayed. These findings support earlier studies conducted in Southern Ethiopia and Northern Kenya (Luseno *et al.*, 2003), Kenya (Silvestri *et al.*, 2012), or Burkina Faso (Roncolli *et al.*, 2009). In these studies, preference was more for seasonal forecast information than for weekly and monthly forecast information. The seasonal forecast information is relayed to inform planning for adaptation, which when implemented enhances resilience building. The study considers seasonal forecast information useful in informing implementation of adaptation strategies aimed at minimizing loss of livestock assets during drought. During the interview with Mr Stanley Kibiwot of NDMA, he echoed the same sentiments by saying;

"Pastoralists utilise seasonal forecasts to outline migration patterns and timing".

This implies that despite the low access and uptake, seasonal forecast information is a useful tool in pastoral decision-making.

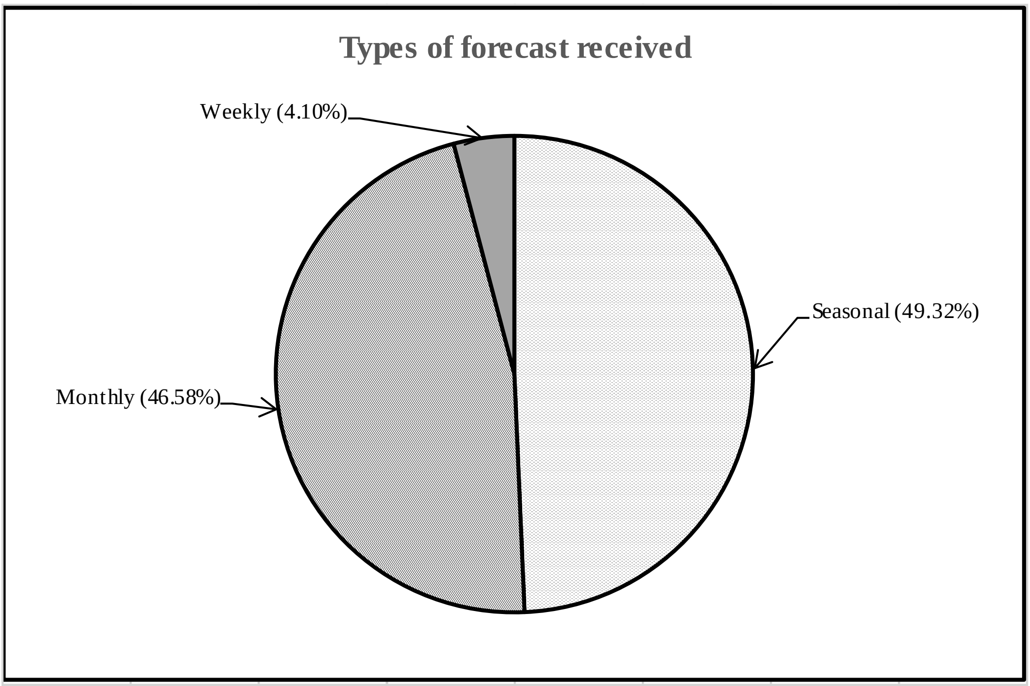


Figure 4.19

Type of climate forecast received in Baringo County

Though a third of the households (33.03%) received climate forecast information, only about a quarter of these (26%) used the information received implying that only a few (7.24%) of the respondents who receive climate information do not use the information in decision-making (Figure 4.20). This corresponds to what Thornton *et al.* (2007a) observed in a case study to that assessed the usefulness of forecasts and determined pastoralists' response to climatic variation and value of use of forecast information. In that study, only a quarter of the pastoralists were willing to use climate forecasts in responding to drought events. In another study, Hayman *et al.*

(2007) estimated 30-50% of farmers do take into account seasonal forecasts when making decisions. Mr Stanley Kibiwot of NDMA indicated that;

"Though the community highly relies on traditional methods of climate forecasting, only pastoralists who receive early warnings are likely to implement them in decision making".

During the key informant interview, Mr Kibiwot said;

"There is a strong relationship between knowledge and uptake of seasonal forecasts among the pastoral communities and very few pastoralists factor in scientific seasonal forecasts in pastoral decision-making".

However, in a study in Arid and Semi-Arid areas of Western Australia to investigate the climate information needs of Gascoyne–Murchison pastoralists, Keogh *et al.* (2006) found that almost three-quarters of the respondents considered climate forecasts in decision-making. This contrast situation observed in the present study. The low uptake of forecasts reflects challenges that pastoralists face in accessing and implementing the climate information. According to Ash *et al.* (2007), the variables of forecasts, the accuracy of the climate information, the associated benefits of the forecasts and the process of communication can affect uptake of seasonal forecasts. In the present sample, use of seasonal forecast for planning adaptation action was more when there was more knowledge of the climate forecast (a correlation of ($r = +0.839$, $p<0.05$) indicating that education would increase uptake of climate forecast information for planning adaptation strategies and increase resilience building among the pastoralists (Figure 4.20).

A significant association between knowledge and usage of seasonal climate forecast ($\chi^2 = 155.726$, p value <0.05) (Table 4.7) was observed in the present study. This concurs with that of Patt *et al.* (2005), who established that, of the 75% smallholder farmers who received seasonal forecast information, 57% changed the planting time and cultivar selection. This demonstrates that knowledge and access influence uptake of climate information. Therefore more effort in dissemination and access of climate information would be a means towards improving uptake of seasonal forecast among the pastoral communities. Uptake would be hastened through improvement in the reliability of forecasts and packaging the message communicated in probabilistic terms (Ash *et al.*, 2007).

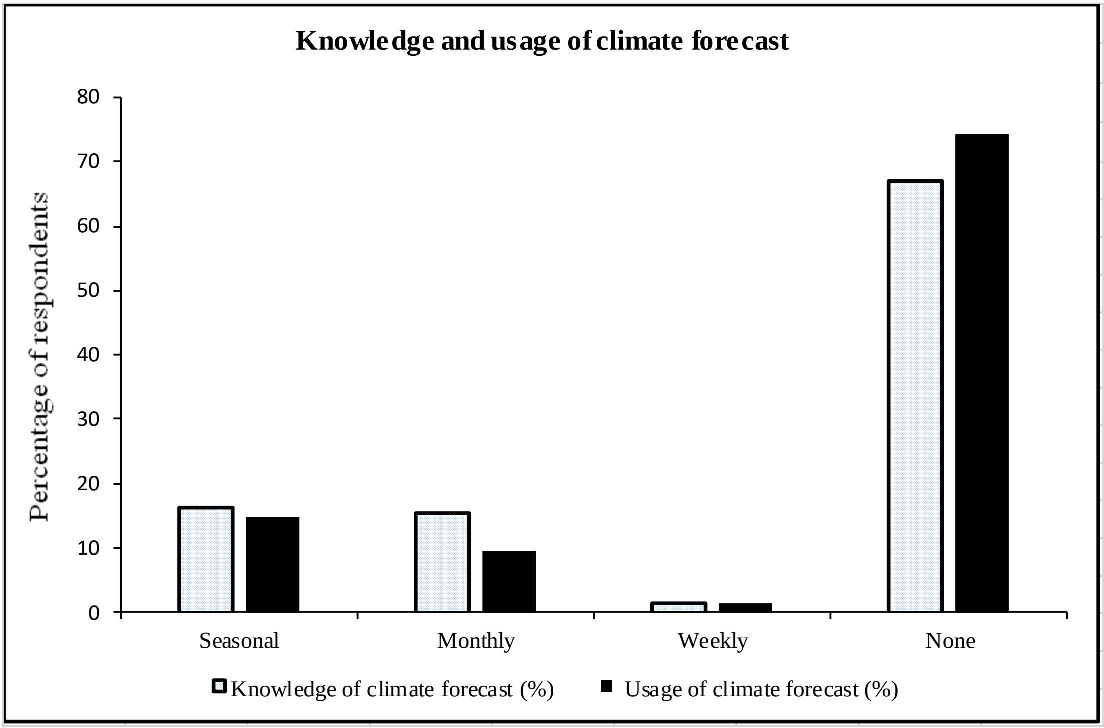


Figure 4.20

Knowledge and usage of climate forecast in Baringo County

Table 4.7
Knowledge and usage of climate forecast

		Knowledge of climate forecast				
		YES	NO	**Total**	χ^2	**p - value**
Usage of climate forecast	YES	57	0	57	155.726	0.000
	NO	16	148	164		
	Total	73	148	221		

Source: Field Data, 2016

4.7 Enabling Conditions for Utilization of Seasonal Climate Forecasts by the Pastoral Households

4.7.1 Use of Climate Information in Decision-making

A majority of the sample population (95%) were aware of the indigenous knowledge of climate forecasting. This high awareness relates to more reliance (72.4%) upon traditional climate forecast methods than the scientific methods (Figure 4.21). According to them, they have relied on this information through the generations, they have remained valuable tools, and therefore majority (94%) give priority to information from indigenous climate forecast methods. However, about one fifth (21.27%) reported combining traditional and scientific forecasts in the face of changing climatic conditions. According to Ajibade & Shokemi (2003), information from indigenous weather forecasting methods with modern forecasting science can build up climate change intelligence and help make the data accessible to both pastoralists and subsistence farming communities.

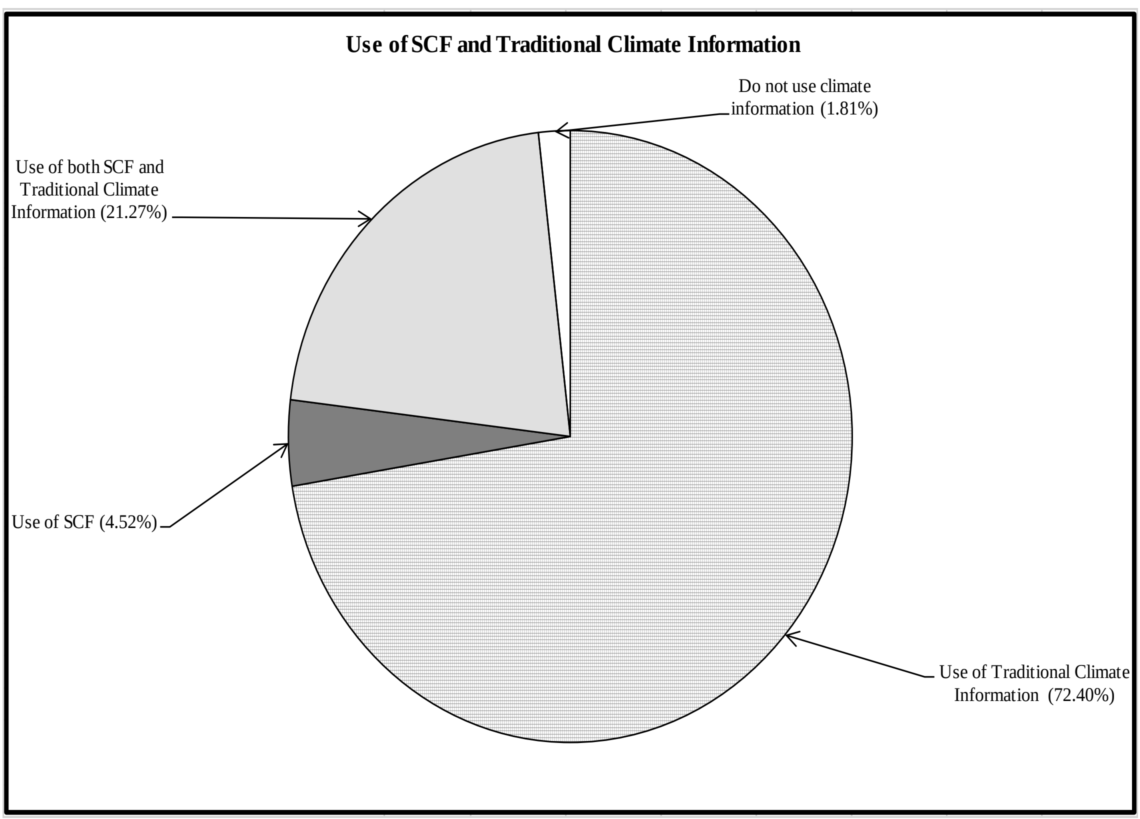


Figure 4.21

Usage of SCF and traditional climate information in Baringo County

Though many communities have relied on traditional climate knowledge, there has been increasing usage of scientific climate information in many parts of Africa (DFID, 2010). Ziervogel & Downing (2004) and Roncolli *et al.* (2009) attributes low adoption of scientific forecasts to limitation of resources such as land, labour, inputs, credit, market access and limited exposure to the use of forecasts, finding that concurs with the present study. Mr Gedion Ndole, Livestock extension officer in Baringo County indicated that;

"The pastoralists in Baringo have their own traditional forecasters that the community heavily relies upon though there is degree of interest among the pastoral community on modern scientific climate forecasting".

Pastoralists use various indigenous strategies of climate forecasting including observing changes in trees, sky, moon, wind and behaviour of animals. Sometimes, they use other traditional indicators including animal intestines (Haruspication – interpretation by inspecting the entrails of sacrificial animals), bird movements, animal behaviour, butterflies, wind direction, heat patterns and use of heavenly formation of stars. Different animals and insects display certain behaviours on the onset of the rainy seasons, for instance, the chipping of insects like cicadas (*Cryptotympana postulata*) and crickets (*Gryllus sp*) was associated with high temperatures at the beginning of the rainy season. The sample population indicated that mosquitoes would be most active during hot periods just before rainfall onset when they bite more.

According to DFID (2010), it is imperative for those responsible for generation and dissemination of seasonal forecasts to collaborate and put in place strategies aimed at removing barriers associated with access and application of climate information. Failure to integrate traditional/local climate knowledge with scientific climate information creates a barrier to uptake of scientific forecasts (DFID, 2010). The study indicates that combining traditional climate knowledge with scientific climate forecasts is a better approach in overcoming challenges involved in the development, communication and uptake of scientific forecasts. The high percentage placed on traditional climate information (72.40%) indicates its significance in decision-making hence it cannot be ignored. Any opportunity to improve uptake of seasonal forecast should be utilised because the forecasts have potential for improving production and livelihood options especially in areas affected by rainfall variability, climate change and drought (Roncolli *et al.*, 2009).

Low uptake of scientific climate forecasts can be associated with over-reliance on official networks of forecast dissemination, which excludes some users from accessing the information (O'Brien & Vogel, 2003). Ziervogel & Downing (2004) suggest an in-depth understanding of the networks of dissemination of climate forecasts and the characteristics of the users.

4.7.2 Barriers to Use of Scientific Seasonal Climate Forecasts in Baringo County

The study further sought to determine the hindrances to use of scientific seasonal forecasts to inform decision making regarding drought events. Table 4.8 presents the findings by percentage responses for first, second and third most important and then computes a weighted mean used to rank the hindrances in their order of importance.

Table 4.8

Hindrances to use of seasonal climate forecasts to respond to drought events

Hindrances to use of seasonal climate forecast (N = 221)				
	Least Important (%)	**Important (%)**	**Most Important (%)**	**Rank (Weighted mean)**
Insecurity/ conflicts	3.6	4.1	92.3	1 ($\bar{y}$ = 2.85)
Illiteracy	5.4	12.7	81.9	2 ($\bar{y}$ = 2.71)
Lack of access to seasonal climate forecasts	4.5	18.1	77.4	3 ($\bar{y}$ = 2.68)
Lack of information	11.3	15.4	73.3	4 ($\bar{y}$ = 2.51)
Lack of diversified sources of income	12.2	21.7	66.1	5 ($\bar{y}$ = 2.42)
Unavailability of credit	23.1	19.0	57.9	6 ($\bar{y}$ = 2.12)
Age of household head	38.0	15.4	46.6	7 ($\bar{y}$ = 1.71)
Culture	46.2	6.3	47.5	8 ($\bar{y}$ = 1.55)
Gender related disadvantages	57.5	2.3	40.3	9 ($\bar{y}$ = 1.26)

Source: Field Data, 2016

An analysis of variance test was done to investigate if the mean ranks were significantly different. The resulting F value was found to be 2.11 with a p value of 0.036. This indicates that the mean ranking of the nine hindrances was significantly different. Of the nine hindrances assessed, the four ranked most important were insecurity/conflicts, illiteracy, lack of access to seasonal forecasts and lack of information, in that order while the least important were gender related disadvantages and culture.

Insecurity and conflicts ranked the first most important major hindrance to uptake of seasonal climate forecast. This is linked to the problem of insecurity and ethnic clashes (Oucho (2002) which are around the structure of access to economic opportunities and redistribution of some of the land formerly owned by the white settlers. The Kalenjin and Maasai communities historically settle most of the land in question. Cases of ethnic clashes erupted towards the end of 1991 and targeted non-Kalenjin, Maasai, Turkana and Samburu inhabitants (Njoroge, 2011). Cases of people killed and livestock stolen still appear frequently in the local press reports. However, the most effective strategy employed by the perpetrators is the destruction of homes and property of the victims in the hope that they would flee to their "ancestral lands" (Anderson, 2002).

Most respondents cited grazing land and cattle rustling as the main cause of ethnic conflicts or tension in the study area. Other main causes mentioned in the interviews include political incitements, racism, poverty and traditions. The perception that there is unequal distribution of resources especially land is attributed to the ethnic conflicts that took place in the study area in 1992, 1997 and 2006 when some ethnic communities were armed to raid and destroy belonging to other ethnic communities (Oucho, 2002; Anderson, 2002). The problem affected all ethnic groupings including the pastoralists. The high ranking of insecurity/conflicts as the most important hindrance can be attributed to the fact that it disrupts normal life making it difficult for pastoralist to focus on access and uptake of seasonal forecast but to save life and property.

The present study established a high degree of illiteracy in the study area with about 42% without formal education and 31% with only primary school level of education. The low illiteracy levels creates a barrier to acceptance of new technologies but more value on indigenous knowledge than scientific knowledge hence creating a barrier to uptake of non-indigenous information. Such communities will not readily participate in workshops or seminars that focus on non-indigenous technologies, making over-reliance on indigenous knowledge a hindrance to use of scientific information. Patt *et al.* (2005) established that farmers who attended workshops about seasonal forecasts were significantly more likely to use the forecasts, a finding that supports the conclusion of the present study. This may be the main reason why access of seasonal forecasts and lack of information is ranked third and fourth respectively as the most important hindrances to use of SCFs in the study area. This is supported by Luseno *et al.* (2003) and Kijazi *et al.* (2013) Nindi that pastoral communities have various early warning indicators based on indigenous formulated and disseminated by council of elders (UNEP, 2008). Communities that have depended on indigenous knowledge believe that neglect of indigenous knowledge in decision-making may lead to environmental deterioration while appropriate uptake is a guarantee to environmental conservation. Continued use of indigenous knowledge on climate information along scientific climate information has made Reyes-García *et al.* (2016) suggest an urgent need to review the strengths and weaknesses and complementarities of indigenous and scientific knowledge in climate information use.

Mr Ndole of department of livestock production in Baringo County identifies a different channel of dissemination of seasonal forecast that he treats as a barrier to uptake of seasonal forecasts among the pastoralists in Baringo County. He said,

"Scientific forecasts through the county meteorologist are done through the emails which might not be accessed by everybody".

He lays emphasis on the need of workshops to disseminate both scientific and traditional forecasts, more so stressing the significance of integrating both the traditional and scientific forecasts. Mr Kibiwot of NDMA on the other hand indicated said that;

"The Early Warning Bulletins released by NDMA contains vital information that can help prepare the pastoralists on forthcoming drought events. The department uses flags during the market days to symbolise various drought phases: normal, alert, alarm and emergency".

Mr Kibiwot confirms that the community appreciates use of this method as compared to other means of communicating scientific climatic information. He identifies several barriers to uptake of seasonal forecast information. This includes lack of synergy between indigenous traditional knowledge and sciences, an aspect that emphasises the need to integrate traditional scientific forecasts with traditional climate information and concurs with Mr Ndole. Other barriers include inability to perfectly translate technical and scientific climate aspects into simple local terms that the community can comprehend. This supports the ranking of illiteracy by the present study as one of the main hindrances to uptake of seasonal forecast information. With improved formal literacy and knowledge of forecast terms among the pastoralists, communication of climate information into local language may not be of great necessity. Mr Kibiwot further identified underfunding as a factor that undermines production, dissemination, quality and uptake of seasonal forecasts. He said

"there is need for proper funding to facilitate generation of high resolution climate data, dissemination of processed climate forecast information and provision of options to respond to adverse climatic conditions in pastoral lands".

4.7.3 Enabling Institutions in the Use of Seasonal Climate Forecasts

Table 4.9 shows five enabling institutions assessed to identify which of them have a greater influence on the dissemination, access and uptake of scientific climate information.

Table 4.9

Enabling institution for dissemination, access and uptake of scientific climate information

	Enabling conditions (N = 221)			
	Not Effective (%)	**Effective (%)**	**Most Effective (%)**	**Rank (Weighted mean)**
Media	15.4	2.7	81.9	1 ($\bar{y}$ = 2.51)
Traditional climate information	16.3	13.6	70.1	2 ($\bar{y}$ = 2.38)
Extension services	36.7	8.6	54.8	3 ($\bar{y}$ = 1.82)
Research organisations	61.1	8.1	30.8	4 ($\bar{y}$ = 1.09)
Laws & policies	68.3	26.2	5.4	5 ($\bar{y}$ = 0.69)

Source: Field Data, 2016

An analysis of variance test was done to investigate if the mean ranks were significantly different. The resulting F value was found to be 3.04 with a p value of 0.029. This indicates that the mean ranking of the enabling conditions was significantly different. The media, traditional/local climate information and extension services, research organisations, laws and policies in that order ranked in effectiveness as an enabling condition for dissemination, access and uptake of scientific climate information. The high effectiveness of media can be attributed to the fact that 81% of respondents owned radios and 15% had access to daily newspapers. Only 4% of the respondents owned televisions. This forms a good avenue for dissemination and access of scientific climate information. This finding conforms to the established correlation ($r = +0.839$, $p<0.05$) between knowledge and usage of scientific climate information. High access and penetration of media amongst the pastoralist community provides the best platform for enlightening the target population of the significance of scientific climate information and distribution of the forecast. This finding is supported by Hansen *et al.* (2011), who considers the print, audio and visual media as the traditional channel for dissemination of weather forecasts to the public. The importance of media varies in form, place and time, with radio the most frequently used in the rural countryside. In support of media, Mr Ndole of livestock production department said that;

”Seasonal forecasts disseminated through the media should always be done in both national and local language”.

The study finding ranks traditional climate information sources as the second most effective enabling condition influencing uptake of seasonal climate forecast. From the household survey, the respondents value traditional climate information sources because they are readily available especially for those who do not own radios, television or cannot access newspapers. Most parts of the study area has weak internet connection making it difficult for pastoralists to access climate forecasts through the internet. More so, the respondents depend on the climatic information they access from friends, relatives, neighbours, administration personnel (chiefs, sub-chiefs, etc). According to the respondents, since most household heads are concerned about the nature of the up-coming season, as the season approaches, conjectures about the likely rainfall/drought scenario constitute the most common topic in social encounters. Residents exchange greetings and often update one another on the climate situation of their respective villages, commonly and locally referred to as ‘eating news’. Ngugi *et al.* (2011) recorded similar findings in their study among the smallholder agro-pastoralists in Machakos District where they found that inter-personal contacts were the most common source of climate forecast information due to the absence of other sources such as radio or television. It is therefore important to factor in the role of traditional climate information in developing effective approaches at improving uptake of seasonal forecasts. Mr Ndole of livestock production department stresses the need of integrating scientific and traditional methods of climate forecasting as a means of improving uptake of scientific climate information.

Extension services ranked third most effective enabling condition to uptake of scientific climate information. The study attributes this to weak extension structures in the study area. In a study to examine the effectiveness of seasonal forecasts and regional climate-risk management strategies in Southern Africa, Vogel & O'Brien (2006) established that extension agents that are weak operationally, affects the flow of climate information between the producers of the information to end users. Swanson (2006) in a study to assess the changing role of agricultural extension in a global economy, acknowledges the importance of extension services shifting from food security to increasing farm income, an indication that extension services has an important role to play in livestock production. A strong extension service system should not only exist by name but must refocus on getting farmers organised through building social capital, forming a channel though which climate forecasts is disseminated, increasing farm income and help alleviate rural poverty (Swanson, 2006). The role of such systems is to meet the needs of the rural pastoral community.

Mr Kibiwot of NDMA suggests that other than the above-mentioned enabling conditions that he fully supports, there is need for awareness campaigns on importance of seasonal forecasts among the pastoral community. He believes that this can help improve uptake of climate information among the pastoralists. He said;

"There is need for creation of local community chat-bases, where discussion on forecasts can be undertaken in local language. This should be a frequent exercise coordinated by the local authorities".

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

The study assessed drought effects on livestock assets and conditions enabling better use of seasonal forecasts among pastoral communities in arid and semi-arid agro ecosystems of Baringo County. The objective was to determine trends and severity of drought events, perceptions and observed effects of droughts on livestock assets, effectiveness and usefulness of seasonal forecasts in predicting the observed drought events, and the enabling conditions for better use of the seasonal climate forecast.

The drought events in Perkerra and Nginyang were associated with a general declining rainfall from 1970 to 2008 periods and peaks in 1982 and 1997, oscillating rainfall for the period 1970 – 2013 with four peaks in 1977, 1988/89 and 1997 and 2007 and very low mean annual rainfall in 2000 (21.4 mm) and in 2002 (19.8 mm). Very low rainfalls (3.29 to 13.33 mm) below the long-term annual average featured in 1974, 1976, 1980, 1991, 1996, 1999, 2000 and 2009 while four extreme catastrophic drought periods were observed in 1984, 2000, 2002 and 2004 in Perkerra with high rainfall events preceded most of the catastrophic drought events.

The drought effects on livestock is manifested as drying up of pastures and water sources and livestock deaths and reduction of livestock market value. Cattle and sheep were more vulnerable while goats, camel, poultry and donkey were more resilient to drought. During droughts, pastoralists' response included livestock migration, but the strategy was associated with loss of livestock through pest and diseases, cattle rustling and conflicts.

Relayed climate forecasts was 85.71% (MAM season) and 80% (OND season) of the times effective and 75% (MAM season) and 57.14% (OND season) of the times useful in predicting the observed drought events. About a third (67%) of the households did not have knowledge about seasonal forecasts attributed to illiteracy and low value for seasonal forecasts released by KMS. Seasonal forecasts was the most received climate information and had high preference by pastoralists for being more reliable and released in time for planning adaptation action.

The four ranked most important hindrances to use of scientific seasonal forecasts in informing decision making regarding drought events were insecurity/conflicts, illiteracy, lack of access to seasonal forecasts and lack of information. For effectiveness as an enabling condition for dissemination, access and uptake of scientific climate information, ranked in order of importance were media, traditional climate information and extension research.

5.2 Conclusions

From the findings presented, the researcher made conclusions based on the research questions.

Research question 1: *What has been the trends and severity of drought events during 1970 – 2013 periods in LM5 and IL6 agro-ecological zones?* There was decline in rainfall between 1970 and 2008 with marked peak periods and extreme low rainfall corresponding to extreme climatic events. Droughts re-occurred within shorter interval and were disruptive to livestock asset based livelihoods. The study concludes that the area will continue to experience decreasing trends in total annual rainfall, re-current droughts and even become drier over time.

Research question 2: *What are the perceived and observed effects of drought events on livestock assets?* The study concludes that different livestock species respond differently to rainfall variability and drought events. Cattle and sheep are highly vulnerable to drought events as compared to goats and camel. Rainfall variability and drought events correspond with fluctuations in the number of livestock owned, body conditions, milk production and market prices of stock and product prices, which are associated with marked scarcities in water, pastures, and induced trekking.

Research question 3: *To what degree are the seasonal climate forecasts effective and useful in predicting the observed drought events?* From the study findings, the seasonal forecasts was 85.71% (MAM), 80% (OND) of the times effective, 75% (MAM), and 57.14% (OND) of the times useful in predicting the observed drought events. Based on the high effectiveness and predictive values, the study concludes that the seasonal forecasts are effective in predicting drought events and therefore a useful tool in decision-making.

Research question 4: *Are there enabling conditions for utilization of seasonal climate forecast in pastoral community areas?* The study concludes that insecurity/conflicts, illiteracy, lack of access to seasonal climate forecasts and lack of information are the most significant barriers to access and uptake of seasonal climate forecasts. They inhibit effective utilization of seasonal forecasts in decision-making. The study further indicates that the media, traditional climate information and extension services are the most effective enabling institutions for dissemination, access and uptake of scientific climate information.

5.3 Recommendations

Based on the research findings, the study makes the following recommendations:

i. The study findings established that the study area is prone to catastrophic and severe droughts. Given the average climatic conditions, the same trend is likely to be displayed in other ASAL areas. The study therefore recommends exposure of pastoralists to information about drought trends and severity to help them understand and appreciate the state of drought, associated effects and the future of pastoral livelihood in the study area. This is important in improving uptake of new technologies aimed at building pastoral resilience. It is also important to equip the existing meteorological stations with modern technology and trained personnel to improve acquisition and management of high-resolution climate data useful in informing the pastoral community on drought trends and severity.

ii. The present study results indicate that drought negatively affects livestock production, with cattle and sheep grossly affected. It therefore recommends an increased investment and restocking in goats, camel and donkey stock which are more resilient livestock species. The study further recommends diversification of livelihoods to enable the pastoral community spread risks associated with drought events. This involves engagement in both pastoral, agro-pastoral and non-pastoral livelihood options. This should be undertaken not only in Baringo County but also in other ASAL areas in Kenya. This will help cushion pastoralists against adverse effects of drought in the study area.

iii. Based on concurrence between climate forecasts and observed drought events in the study area and established positive and significant correlation between knowledge and usage of seasonal forecasts, the study recommends intensified dissemination, access and utilization of scientific seasonal climate forecasts among the pastoral community in all arid and semi arid lands in Kenya.

iv. The study identified barriers and enabling conditions to access and uptake of seasonal climate forecast. The Extension agencies and media should be empowered to enhance their capacity to dissemination and access of climate information in the study area. There is need to integrate traditional climate information with scientific climate in order to improve uptake of seasonal forecasts. This will help build pastoral resilience in arid and semi arid lands in Kenya.

5.4 Recommendation for Further Research

The present study highlights the following areas for further research:

i. Further research should focus on case studies to quantify the impact of usage of seasonal forecasts on specific livestock asset, an aspect that the present study could not address.

ii. Further study should be undertaken to establish the best approaches in integrating traditional climate knowledge with scientific climate knowledge as an option of overcoming challenges involved in the development, communication and uptake of scientific forecasts.

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APPENDICES

Appendix I: questionnaire for Farmers

Preamble

I am Richard Ochieng', a graduate student from Geography Department - Egerton University, pursuing Doctor of Philosophy Degree in Geography. I am involved in conducting a study whose main purpose is to help assess drought effects and use of seasonal climate forecasts on pastoral livestock assets Arid and Semi-Arid Baringo County. This questionnaire contains a number of questions that will assist me to gain understanding. It is my request that you kindly provide the necessary answers to the respective questions here presented. I take this opportunity to assure you that any information you volunteer will be treated with utmost confidentiality and be used for academic purpose only. Allow me to thank you most sincerely for sparing your valuable time to assist by answering the questions.

Questionnaire No. ………

Study site: Kositei (IL6) ☐ Nginyang west (IL6) ☐ Salabani (LM5) ☐ Ngambo (LM5) ☐

Date…………

Please tick the appropriate response or give a brief comment where applicable

<u>Part A: Personal details</u>

1. Name of Respondent: ……………………………………………………………
2. Gender of the household head: [1] Male [2] Female
3. Education level:

   [1] No formal education [2] Primary and below [3] Secondary [4] Post-secondary
4. Age bracket of household head:

   [1] Below 18 [2] 18-30 [2] 31-40 [3] 41-50 [4] 51-60 [5] 61+
5. Occupation:

   [1] Pastoralist [2] Other (Specify)………………………
6. Respondent's relation to household head

   [1] Household head (Self) [2] Wife [3] Other (Specify)**…………..**

Part B: Socio-economic factors

7. Grazing land under pasture/fodder:

Type of tenure	**Acreage**
a. Own purchased	
b. Inherited	
c. Leased	
d. Communal	
e. Government land	

8. Livestock reared:

	Type of Livestock	Total
a.	Cattle	
b.	Goats	
c.	Sheep	
c	Camels	
d	Donkeys	
e	Poultry	
f	Others (specify)	

9. a. Has any of your livestock died in the past 5 years? YES ☐ NO ☐

b. If yes, what was the main cause?

Disease ☐ Drought ☐ Conflict ☐ Predation ☐ Others (Specify)……….

Part C: Drought events

10. Have you ever noticed the following changes over the last 5 years?

	Trend over the last 5 years (Tick the appropriate trend)			**Reason for observed change**
	Increasing	**Decreasing**	**No-change**	
a. Amount of rainfall				
b. Distribution of rainfall				
c. Number of rain days				
d. Severity of drought				
e. Frequency of drought				

Part C: Effects of drought on pasture/fodder and livestock production

11. What specific livestock are affected by drought? (Rank on a scale of **1 - 3**: **3 -** Very severe; **2** – Moderately severe; **1** – Not severe)

Livestock	**Rank**
Cattle	
Sheep	
Goats	
Camel	
Donkey	
Poultry	
Others (specify)	

12. Kindly use the options below to rank the negative effects of drought:

5 – Strongly agree, 4 – Agree, 3 – Undecided, 2 – Disagree, 1 – Strongly disagree

Negative Effect	**Rank**
a. Lowers prices of livestock	
b. Affects prices of livestock products	
c. Affects pasture development	
d. Destruction of watering points	
e. Decline in livestock products	
f. Increased incidences of livestock pests and diseases	
g. Drying up of livestock pastures	

13. Based on your experience as a pastoralist, what has been the main determinant of livestock production in Baringo County?

Financial capital ☐ Health ☐ Education ☐Rainfall ☐ Other (specify) …………………

Part D: Adaptation strategies used by pastoralists to respond to drought events

14. Rank the following adaptation strategies according to effectiveness in responding to drought events:

3 - Most effective **2** – Effective **1** – Not effective

Adaptation strategies	**Rank**
a. Keeping different livestock species	
b. Reducing the herd size	
c. Engaging in other economic activities (specify)	
d. Relocation to other places	
e. Changing the extent of land put under grazing	
f. Practicing mixed farming	
g. Embracing non-farm economic activities	
h. Reliance on remittances from other family members	
i. Disposing off livestock during drought seasons and restocking during rainy season	
j. Use of seasonal climate forecasts	
k. Others (specify)	

15. Kindly use the options below to rank the hindrances to adaptation strategy to drought events:

3–Most important, **2**-Important, 1–Least important

Factor	**Rank**
a. Lack of information	
b. Lack of access to seasonal climate forecasts	
c. Illiteracy	
d. Culture	
e. Lack of diversified sources of income	
f. Unavailability of credit	
g. Age of household head	
h. Gender related disadvantages	
i. Ethnic conflicts	

16. Have you received any training on access and use of climate forecasts? YES ☐ NO ☐

17. If YES, by which organisation? ....

18. How has the training helped you to adapt to drought events? Yes ☐ No ☐
Explain..

19. Do you think the current adaptation strategies are effective and sustainable? YES ☐
NO ☐

20. If NO, What should be done to develop effective and sustainable adaptation strategies to drought events?..................................... ....
....
....

21. Identify and rank institutions that create enabling conditions for access and use of seasonal climate forecasts in Baringo County.

3 - Most effective **2** – Effective **1** – Not effective

Enabling institution	**Rank**
a. Media	
b. Extension services	
c. Laws & policies	
d. Research organizations	
e. Traditional climate information	
f. Others (specify)	

Part E: Seasonal Climate Forecasts

22. Are you aware that KMS regularly issues seasonal climate forecasts at the beginning of every onset in Kenya? Yes ☐ No ☐

Explain…………………………………………………………………………………………

…………………………………..

23. Did you receive or access seasonal climate forecasts for the last season? Yes ☐ No ☐

Explain…………………………………………………………………………………………

……………………………….……………………………..……………………………..

24. What is the type of forecast information you received?

Seasonal ☐ Monthly ☐ Weekly ☐ Daily ☐

Explain…………………………………………………………………………………………

……………………………….……………………………..……………………………..

25. Do you factor seasonal climate forecasts in the planning and implementation of livestock production decisions? Yes ☐ No ☐

Explain…………………………………………………………………………………………

……………………………….……………………………..……………………………..

26. State the source of your information?

Radio ☐ Newspaper ☐ Television ☐ KMS ☐ Ministry of Agriculture, Livestock and Fisheries ☐ Other (Specify) ……. ……………………………………

Explain…………………………………………………………………………………………

……………………………………..…………………………………..……………………………………..

27. Explain the main barriers that hinder access and use of seasonal climate forecasts by pastoralists in Baringo County?

28. What can you recommend to help improve dissemination, access and use of seasonal climate forecasts?

29. Traditional Climate Information:

a. Are there traditional methods of predicting drought events in your area?

Yes ☐ No ☐

b. If YES, give the details indicated below:

Traditional indicator used	Climate aspect predicted	How long in advance can prediction be made?	Reliability: 1 – Very reliable 2 – Sometimes reliable 3 – Not reliable 4 - Used to be reliable but no longer is

d. Do you use traditional schemes of climate forecast in making livestock production/ management decisions? YES ☐ NO ☐

e. Do you use it in combination with seasonal climate forecast information or separately?
   Yes ☐ No ☐

f. Given a choice, which information would you use first?

   Traditional methods ☐ Seasonal climate forecast ☐
   Explain……………………………………………………………………………

<u>THANK YOU FOR YOUR PARTICIPATION</u>

Appendix II: Key Informant Interview Schedule

Preamble

I am Richard Ochieng', a graduate student from Geography Department - Egerton University, pursuing Doctor of Philosophy Degree in Geography. I am involved in conducting a study whose main purpose is to help assess drought effects and use of seasonal climate forecasts on pastoral livestock assets in Arid and Semi-Arid Baringo County. This Interview schedule contains a number of questions that will assist me to gain understanding. It is my request that you kindly provide the necessary answers to the respective questions here presented. I take this opportunity to assure you that any information you volunteer will be treated with utmost confidentiality and be used for academic purpose only. Allow me to thank you most sincerely for sparing your valuable time to assist by answering the questions.

Interview Schedule No. ………… … AEZ ……………………. Date………………

The Key Informants:

i. Livestock Officers
ii. Climate experts/NDMA Officer

Interview Questions

Name …………………… Occupation ……………Institution ……….. Position……….

1. Kindly explain the rainfall pattern in Baringo for the last 10 years in terms of rainfall onset, cessation and amount.
2. Please give an overview of the annual livestock production in Baringo County.
3. Explain the effects of drought on livestock assets (number livestock owned, milk production, mortalities/deaths/livestock prices) in Baringo County.
4. Explain how pastoralists utilize seasonal climate forecasts in Baringo County.
5. What is the main source of information regarding seasonal forecasts in Baringo County?
6. Explain the main barriers that hinder access and use of seasonal climate forecasts by pastoralists in Baringo County.
7. What can you recommend to help improve dissemination, access and use of seasonal climate forecasts?

THANK YOU FOR YOUR PARTICIPATION

Appendix III: SA(t) values in relation to the drought severity in Perkerra region

Year	Total Annual Rainfall	SA(t)	Severity of Drought Event
1970	696.40	2.51	Not Severe
1971	769.90	2.95	Not Severe
1972	562.90	-1.12	Catastrophic Drought
1973	431.00	-4.84	Catastrophic Drought
1974	736.90	2.26	Not Severe
1975	769.80	2.78	Not Severe
1976	475.80	-3.78	Catastrophic Drought
1977	1085.30	5.73	Not Severe
1978	756.40	3.36	Not Severe
1979	651.60	1.48	Not Severe
1980	427.50	-3.78	Catastrophic Drought
1981	692.10	2.04	Not Severe
1982	666.70	1.20	Not Severe
1983	703.30	1.47	Not Severe
1984	270.50	-13.85	Catastrophic Drought
1985	714.40	1.96	Not Severe
1986	510.60	-1.99	Catastrophic Drought
1987	587.00	-0.32	Severe Drought
1988	892.90	4.33	Not Severe

1989	842.00	4.45	Not Severe
1990	590.50	-0.34	Severe Drought
1991	667.50	1.28	Not Severe
1992	565.00	-1.00	Catastrophic Drought
1993	654.90	1.53	Not Severe
1994	563.40	-0.86	Severe Drought
1995	500.10	-3.48	Catastrophic Drought
1996	539.70	-1.50	Catastrophic Drought
1997	780.80	2.66	Not Severe
1998	760.40	2.48	Not Severe
1999	637.60	0.56	Not Severe
2000	256.90	-19.05	Catastrophic Drought
2001	411.20	-7.08	Catastrophic Drought
2002	237.60	-15.29	Catastrophic Drought
2003	275.40	-9.56	Catastrophic Drought
2004	275.80	-14.17	Catastrophic Drought
2005	626.60	0.61	Not Severe
2006	529.30	-2.03	Catastrophic Drought
2007	926.80	6.17	Not Severe
2008	452.40	-3.34	Catastrophic Drought

Appendix IV: SA(t) values in relation to the drought severity in Nginyang region

Year	Total Annual Rainfall	SA(t)	Severity of Drought Event
1974	10.31	-14.14	Catastrophic Drought
1975	16.47	-3.82	Catastrophic Drought
1976	10.77	-11.10	Catastrophic Drought
1977	27.90	1.45	Not Severe
1978	33.56	3.33	Not Severe
1979	36.58	4.81	Not Severe
1980	11.34	-8.62	Catastrophic Drought
1981	37.54	2.80	Not Severe
1982	48.16	4.27	Not Severe
1983	18.76	-1.61	Catastrophic Drought
1984	18.00	-2.34	Catastrophic Drought
1985	37.77	3.60	Not Severe
1986	17.09	-2.94	Catastrophic Drought
1987	22.47	-0.38	Not Severe
1988	33.54	2.21	Not Severe
1989	27.08	1.23	Not Severe
1990	28.88	1.87	Not Severe
1991	13.33	-8.99	Catastrophic Drought
1992	18.21	-2.99	Catastrophic Drought
1993	25.44	0.69	Not Severe
1994	17.57	-3.04	Catastrophic Drought
1995	28.36	1.44	Not Severe
1996	10.57	-13.16	Catastrophic Drought
1997	47.46	4.10	Not Severe
1998	29.73	2.28	Not Severe
1999	11.12	-8.73	Catastrophic Drought
2000	3.29	-18.42	Catastrophic Drought
2001	19.86	-1.70	Catastrophic Drought
2002	29.21	1.76	Not Severe

2003	23.54	0.01	Not Severe
2004	28.87	1.75	Not Severe
2005	18.91	-1.76	Catastrophic Drought
2006	27.72	1.14	Not Severe
2007	15.45	-6.31	Catastrophic Drought
2008	22.26	-0.44	Not Severe
2009	12.74	-6.21	Severe Drought
2010	12.19	-11.30	Catastrophic Drought
2011	27.95	0.96	Not Severe
2012	25.47	0.67	Not Severe
2013	35.20	2.87	Not Severe

Appendix V: NACOSTI Permit

THIS IS TO CERTIFY THAT:
MR. RICHARD OCHIENG OYUGI
of EGERTON UNIVERSITY, 0-80403
Kwale,has been permitted to conduct research in *Baringo* *County*

on the topic: *ASSESSING EFFECTS OF DROUGHT AND USE OF SEASONAL CLIMATE FORECASTS ON PASTORAL LIVESTOCK ASSETS IN ARID AND SEMI-ARID BARINGO COUNTY, KENYA*

for the period ending:
23rd May,2017

Permit No : NACOSTI/P/16/9109/11008
Date Of Issue : 24th May,2016
Fee Recieved :Ksh 2000

Applicant's Signature

Director General
National Commission for Science, Technology & Innovation

Appendix VI: NACOSTI Research Authorization Letter

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

NACOSTI/P/16/9109/11008

Date:

24th May, 2016

Richard Ochieng Oyugi
Egerton University
P.O Box 536-20115
EGERTON.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessing effects of drought and use of seasonal climate forecasts on pastoral livestock assets in arid and semi-arid Baringo County, Kenya."*** I am pleased to inform you that you have been authorized to undertake research in **Baringo County** for the period ending **23rd May, 2017.**

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

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Baringo County.

The County Director of Education
Baringo County.

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