UNIVERSITY OF NAIROBI

IMPACTS OF CLIMATE VARIABILITY AND WEATHER FORECASTS ON LIVESTOCK PRODUCTION AND MARKETING IN BARINGO COUNTY, KENYA

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I wrote this thesis in my own words, except few quotations that I adopted from published and unpublished sources, which I have highlighted and acknowledged by referencing them. I understand that obtaining materials from external sources or even paraphrasing them without acknowledgement would be treated as plagiarism in line with customs and according to the University Regulations on Conduct of Examinations. I have, therefore, indicated the sources of all maps, illustrations and pictures that I have utilized in this thesis, which are not my original work.

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DEDICATION

I dedicate this work to my late father Johana Muriithi Minjire and mother Lydia Njoki, who supported me all the way since the beginning of my life. They kept on encouraging me to take up education for better life although they were illiterate.

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ABSTRACT

The study focused on the impacts of climate variability and weather forecasts on livestock production and marketing in Mogotio and Marigat sub-counties in Baringo County, Kenya. The pastoralists have continued practicing livestock production and marketing without reliable climate/ weather forecasts in the face of increasingly variable climate. The specific objectives of the study were to: examine the impacts of seasonal climate variability on livestock production and marketing; determine the performance of indigenous and conventional climate forecasts over the study period; establish the impact of indigenous and conventional seasonal weather forecasts on livestock production and marketing in a changing climate; and recommend interventions to enhance efficiency and effectiveness in livestock production and marketing in the context of climate change. Diverse methodologies were applied in the study. Station average and Theissen polygon methods were used to estimate the mean areal precipitation of the study area over a 30 year period (1974-2003). A cross-sectional household survey, two focus group discussions, 10 key informant interviews (KII) and one stakeholder engagement forum were undertaken. Using a simple random sampling technique, 454 households were sampled for the survey. Both descriptive and inferential statistics were performed for the precipitation and temperature trends using Microsoft Excel, while Statistical Package for the Social Sciences (SPSS) Version 20 was used to analyze the household survey data. The focus group discussions were transcribed and developed into themes. Based on the results, the range of the estimated mean areal precipitation was 803.20 mm to 939.05 mm. Linear regression line showed a decline in rainfall of 2.4 mm and 4.72mm per year by use of the station average and Theissen polygon methods, respectively. This was because the four stations where the former method was used covered 2757 km^2 and were located in the lowlands while the six stations for the latter method covered a wider area of 3905.76 km^2 and within the highlands. Both were over pointed by high variability. A majority (68.2%) of the pastoralists and agro-pastoralists were not aware that they could access a blend or a mix of indigenous traditional knowledge (ITK) and conventional weather forecasting advisory services in the study area. Also, a significant portion (29%) of the pastoralists and agro-pastoralists revealed that the popularity of ITK weather forecast among the Arid and Semi-Arid Lands communities was as a result of being easily interpreted by the local communities. Findings from focus group discussions (FGDs) and key informants interviews (KIIs) revealed that pastoralists and agro-pastoralist generally believed more in conventional methods as reliable weather predictor for extreme climatic events such El Niño and droughts. A majority of the pastoralists interviewed expressed the view that the indigenous knowledge practiced in weather forecasting had a positive impact on the calving rates (65.1%), calving interval (62.4%), fertility (52.4%), growth rate (50.3%) as well as the milk production (46.4%) of their livestock. A majority (31%) of the interviewed key informants reported that the level of farmer preparedness before extreme weather or climate risks had a positive impact on the performance of livestock productivity and marketing. The majority (32.84%) of the respondents reported that they controlled breeding of their livestock as a means of averting adverse impacts of seasonal climate variability. Climate change and variability impact in the area were averse to livestock production and marketing. Based on the findings of this study it was concluded that seasonal weather forecast-based planning can be an appropriate climate change adaptation strategy informed by a reliable blend or mixture of ITK and conventional weather forecasting advisory services. The study recommends an up-scaling of existing seasonal rainfall advisories based on participatory scenario planning and knowledge integration.

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LISTS OF ABBREVIATIONS/ACRONYMS AND SYMBOLS

ArcGIS	-	Arc Geographical Information System
ASAL	-	Arid and Semi-Arid Land
ASDSP	-	Agricultural Sector Development Support Programme
CITK	-	CARE International Kenya
CP	-	Crude Proteins
CRU	-	Climatic Research Unit
CV	-	Climate Variability
ESA	-	East and Southern Africa
FAO	-	Food Agricultural Organization
FGD	-	Focus Group Discussion
GHG	-	Greenhouse Gas
GOK	-	Government of Kenya
GPS	-	Global Positioning System
IBM	-	International Business Machines Corporation
ICSU	-	International Council for Sciences
IDRC	-	International Development Research Centre
IFAD	-	International Fund for Agricultural Development
ILRI	-	International Livestock Research Institute
IPCC	-	Intergovernmental Panel on Climate Change
ITF	-	Indigenous Technical Knowledge Forecasts
ITK	-	Indigenous Traditional Knowledge
JKUAT	-	Jomo Kenyatta University of Agriculture and Technology
KALRO	-	Kenya Agricultural and Livestock Research Organisation
KGA	-	Kimalel Goat Auction
KI	-	key informant
KMD	-	Kenya Meteorological Department
MAM	-	March, April and May
NDMA	-	National Drought Management Authority

NACOSTI	-	National Commission for Science, Technology and Innovation
OND	-	October, November and December
PM	-	Primary Market
PSP	-	Participatory Scenario Planning
SCF	-	Seasonal Climate Forecasts
SON	-	September, October and November
SRA	-	Seasonal Rainfall Advisories
SPSS	-	Statistical Package for the Social Sciences
WISP	-	World Initiative for Sustainable Pastoralism
ECF	-	East Coast Fever
CCP	-	Contagious Caprine Pleuropneumonia
LIC	-	Livestock Improvement Center

DEFINITION OF KEY TERMS

Adaptation to climate change: Refers to adjustment made in human and/or natural systems in response to anticipated climatic stimuli and their effects as a way of moderating their effects on environment. Some of the adaptation methods might be planned, private or public in nature, reactive or even anticipatory (IPCC, 2014a).

Agro-ecological zones: entails the identification, characterization and categorization of the physical environmental resources which are meaningful for assessment of probable agricultural production systems. The physical resources include climatic components, soils, and land form, basic water supply, energy nutrients and physical support (Fische et al., 2002).

Climate Change: the variability that occur in climate over time due to human activities (IPCC, 2014a).

Climate Variability: According to IPCC (2014a), they are the differences in mean, standard deviation and other statistics recorded in climate. The differences might be due to internal processes within systems utilized to measure climate or external forces.

Environmental Degradation: It is the depletion of environmental resources due to soil, air or water erosion emanating from changes in climate and unpredictable weather conditions. Also, it includes the destruction of ecosystem including wildlife extinction (Rani, 2016).

Extreme Climatic Events: These are climatic conditions that are beyond predictable ones. They might therefore be termed as unusual, unexpected and unpredictable from the historical ones (Zeyaeyan et al., 2017).

Indigenous Traditional Knowledge: refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds (Inter-agency support group on indigenous peoples' issues report, 2014).

Livestock Marketing: Involves the sale, purchase or exchange of products such as live animals, milk, wool and hides for cash or goods in kind. When sales (or purchases) are made in cash, the price paid to (or by) the producer is known as the market price (Addis, 2017).

Mean Areal Precipitation: Average amount of precipitation received in a specified period of time in an area (Chin, 2007).

Participatory Scenario Planning: Is a process for collective sharing and interpretation of climate forecasts (GOK, 2014a).

Pastoralists: Are livestock producers who grow no crops and simply depend on the sale of exchange of animals and their products to obtain foodstuffs. Such producers are most likely to be ‘nomads’ i.e. their movements are opportunistic and follow pasture resources in a pattern that varies from year to year (Blench, 1999).

Agro-pastoralists: Settled pastoralists who cultivate sufficient areas to feed their families from their own crop production. They hold land rights, use their own or hired labour to cultivate land and grow staples. While livestock are still valued property, their herds are on average smaller than other pastoral systems, possibly because they no longer solely rely on livestock and depend on a finite grazing area around their village which can be reached within a day (Blench, 1999).

Resilience: Is the ability to absorb disturbances, to be changed and then to re-organise and still have the same identity (retain the same basic structure and ways of functioning). It includes the ability to learn from the disturbance. A resilient system is forgiving of external shocks. As resilience declines, the magnitude of a shock from which it cannot recover gets smaller and smaller (Resilience Alliance, 2002).

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Over the last few years, rising temperatures and unpredictable rainfall have emerged as serious global problems. According to Jiri et al. (2014), they threaten sustainable development due to their adverse effects on physical infrastructure, natural resources, food security, economic activities, human health and environment in general.

The main challenge that faces farmers in arid and semi-arid areas of Sub-Saharan Africa is managing unreliable rainfall (Tumbo et al., 2010). Rain-fed agriculture dominates in Sub-Saharan Africa. This kind of agricultural practice covers around 97 percent of total cropland but is exposed to the risks of high seasonal rainfall variability (Calzadilla et al., 2008; Tumbo et al., 2010). In spite of this, accurate seasonal weather predictions for between 3 and 6 months can help farmers and other relevant stakeholders in agriculture industry to reduce the effects of unpredictable weather conditions by making decisions that can help them to mitigate the environmental effects emanating from bad weather. The predictability of seasonal weather patterns and their influence on crop and livestock production hints that agricultural applications of seasonal weather predictions may be important to society (Amwata et al., 2018). Thus, the effects of climate change can be reduced significantly by adopting efficient methods of predicting weather and possible changes in climate. This would enable communities living in rural areas to make informed farming decisions that would be timely and efficient thereby increased productivity (Kijazi et al., 2012).

Zillman (2009) claims that climate related information such as efficient prediction, research and observations play a critical role in adaptation of efficient methods of mitigating changes in climate because they enable farmers to use seasonal weather prediction-based management to increase their crop or livestock production. A primary illustration is where farmers in high potential areas use seasonal weather predictions in managing their dairy herd. Many of the dairy farmers take advantage of the climate outlook, and there may be an over-supply of milk in the market that may bring the price down due to market forces of supply and demand (Wambua 2014).

Studies show that farmers' abilities to anticipate changes in weather conditions and adjust farming practices accordingly within a short time have the capacity to create resilience among them. It therefore serves as a basis for improving food security particularly at this time of drastic climate change and variability in sub-Saharan Africa. However, most African pastoralist communities are characterized by food insecurity, decreased incomes, high poverty levels, and degraded environments. They also lose important grazing lands to cultivation, land grabbers who pursue selfish interests and government for public use. In addition, they face drought, increased population growth and inappropriate development policies (Amwata, 2013).

According to USAID (2015), Kenya is a high-risk food-insecure country. The Arid and Semi-Arid Land (ASAL) supports almost 30% of the total national population and 70% of the livestock production (GOK, 2013a). In the midst of this uncertainty, Amwata (2013) identifies a huge gap between accurate weather predictions and utilization of such predictions in Kenya particularly in relation to making critical decisions relating to agriculture. This gap is applicable to the study area. For instance, in Kenya, in the last few years KMD has been disseminating weather predictions in the outlooks but farmers have not utilized them as expected. To this end, it has been acknowledged that efficient utilization of efficient weather predictions play an important role in minimizing the effects of climate change especially in arid and semi-arid southern African countries (Shilenje et al., 2011).

Odero (2011) reported that pastoral communities in Kenya rely on indigenous knowledge (ITK) systems for adaptation to and management of climatic risks. The Kenya National Drought Management Authority, as a stakeholder in seasonal weather prediction and operating in the study area, has been contributing to the efforts of the Kenya Meteorological Department in providing seasonal weather prediction information for drought monitoring and early warning (Ndegwa., 2018). The National Drought Management Authority is working independently of indigenous seasonal weather predictions which are more popular among the pastoralists. Odero (2011) asserts that seasonal weather predictions based on Indigenous Traditional Knowledge (ITK) is a traditional climate risk management tool among pastoralists.

1.2 Problem statement

The study areas were Baringo South (Marigat) and Mogotio Sub-counties in Baringo County. The two sub-counties lie within the ASAL. The communities residing in the study area rely entirely on livestock production for their livelihood. Livestock production is an agricultural enterprise that is highly sensitive to any slight climate variability and change. Therefore, getting timely and correct climate/weather information can enhance efficiency and effectiveness in animal production and marketing. Water and pasture are the major essentials in livestock production in the ASAL. For this reason, shortage of the two essentials (water and pasture) poses significant challenges to the pastoralists' livelihood. These two essentials have a relationship with climate variability and change. The pastoralists lack a holistic approach to managing the unusual seasonal weather patterns in the context of climate change and variability to plan and make rational decisions on their livestock production and marketing.

The target communities living in the ASAL have an over-reliance on ITK weather forecast approach in managing their livestock in production and marketing within the dry and rain seasons (Odero, 2011). The current problematic situation is that there is an increasingly variable climate, quite unlike in the past (Ochieng et al., 2017). The variability has been observed in the amount of precipitation, air temperature and their trends indicate decline and increase respectively. Frequent extreme climatic events such as droughts and heat waves have been witnessed. The known rainfall patterns and seasons have changed (Lelenguyah, 2013). This situation has posed a problem to the communities in the study area who entirely rely on livestock as their livelihood leading to making of uninformed decisions on livestock production and marketing.

There is scanty information on the effects of climate variability and its forecasting on livestock production and marketing in Baringo County. The pastoralists have continued practicing livestock production and marketing with climate/ weather forecasts which are too coarse in the face of increasingly variable climate. Although the climate change and variability impacts are evident, effective weather forecasting for livestock production and marketing remains a gap in Baringo County.

Communities are increasingly losing livestock, which are the only asset of the poor during prolonged and more frequent droughts, similar to other parts of Africa as noted by several authors (Kadi et al., 2011; Easterling et al., 2007; FAO, 2007; Thornton et al., 2007; IFAD, 2010). This is influenced by factors such as livestock production systems (Thornton et al., 2007) including water and feeds, livestock genetics and breeding, and animal health. Rust and Rust (2013) argued that in future in the developing countries the animals, pasture and other natural forages will be more exposed to the elements such as air temperature and precipitation. It is to be expected that animal husbandry will be more sensitive to change and variability in the climate under these conditions.

The impact of climate variability on livestock production and marketing is worsened by the overreliance by the target communities on ITK weather forecast which is less effective due to an increasingly variable climate in the study area. Risiro et al. (2012) reported that both science-based and traditional methods of forecasting weather have their own weaknesses and strengths and thereby can be combined to develop a more comprehensive method of forecasting weather for the benefits of end-users. Netshiukhwi (2013) argued that scientists utilize methods that are different from those used by traditional farmers to predict possible changes in climate at the start of planting seasons. Over the last few decades, agro-meteorologists, on their part, have developed science-based methods for coping with climate variability, which have proved unreliable due to the climates' unpredictability. As a result, at one time, they advised farmers to plant crops based on the rainfall forecast, but the rainfall failed to come as predicted. Some farmers, especially those that rely heavily on traditional methods of predicting weather, have resorted to utilizing observation methods of predicting weather, which have also proved to be unworkable.

1.3 Research Questions

i. What are the impacts of seasonal climate variability on livestock production and marketing?

ii. How efficient are the weather forecasts ITK and convectional in capturing the climate variability for the study region?

iii. What are the impacts of indigenous and conventional seasonal weather forecasts on livestock production and marketing in a changing climate?

iv. What are the interventions to enhance efficiency and effectiveness in livestock production and marketing in the context of climate change Forecasting and variability?

1.4 Objectives of the study

1.4.1 Broad objective

To examine the impacts of climate variability and weather forecasts on livestock production, and marketing in the face of climate change and recommend interventions for Baringo County, Kenya.

1.4.2 Specific objectives

i. To examine the impacts of climate variability on livestock production and marketing

ii. To determine the performance of ITK and conventional climate forecasts over the study period

iii. To establish the impact of indigenous and conventional seasonal weather forecasts on livestock production and marketing in a changing climate in Baringo County.

iv. To determine the interventions to enhance efficiency and effectiveness in livestock production and marketing in the context of climate change and variability.

1.5 Justification and significance of the study

1.5.1 Justification of the study

In Kenya, approximately 60% of livestock in the country is found in the ASALs, which form roughly 80% of the land in the country. In 2011, the livestock sector contributed nearly 12% of the national Gross Domestic Product (GDP), which formed about 40% of the agricultural GDP and 50% of the labour force in agriculture (Behnke and Muthami, 2011). The arid and semi-arid parts of the country are characterized by high temperatures, low rainfall, poor quality feeds and increased incidences of livestock diseases. This is in spite of the fact that the regions host approximately 50% of livestock in the country and more than a quarter of the population in the country (Kinyamario and Ekeya, 2001). Majority of the people living in the ASALs are pastoralists and they keep indigenous breeds of cattle such as Zebu (Herlocker, 1999). In addition, they rely on livestock for livelihood, which most of the time are affected by adverse climate changes, hence the regions are marked by low human development (e.g. high level of poverty, low literacy, and low population density) but a high growth rate and poor infrastructure (Njoka et al., 2016).

It is important for the pastoralists and agro-pastoralists to integrate ITK and convectional forecasts in order to have adequate climate/weather information that can enable them to make informed decisions leading to avoidance of massive loss in livestock numbers that they have been experiencing due to inadequate timely weather information while making livestock production and marketing decisions. Therefore, an opportunity exists of reducing losses in livestock by integrating ITK and convectional knowledge.

1.5.2 Significance of the study

The livestock keepers are able to choose the best source of climate/weather forecast based on the reliability of the source as per the findings of the study. The recommendations from this study will inform and influence policy in the government as well as the livestock keepers and it will enhance the resilience of the livestock keepers in the ASAL in the face of climate variability and change. The interventions recommended will go a long way in reducing the current and future negative impacts of climate variability on livestock production and marketing in the study area, for improved livelihoods/welfare of ASAL communities at large. The ITK and convectional knowledge that is generated from this study is expected to enhance agro-pastoralists and pastoralists in making rational decisions in livestock production and marketing and escape huge economic losses they encounter.

1.6 Scope and limitations of the study

The study assessed the impacts of seasonal climate variability and weather forecasts on livestock production and marketing in Baringo South (Marigat) and Mogotio Sub-counties, Baringo County, Kenya. Recorded rain gauged precipitation (1974-2003) and gridded maximum and minimum air temperatures (1980-2008) data were used for time series analysis of seasonal climatic variability in Baringo County. Recorded air temperatures data (maximum and minimum temperature) were unavailable; some had data gaps and as such could not be used in the study. Data were sourced from Kenya Meteorological Department for seven stations in the study area. For the time series analysis, the data set for six stations was used for the entire County and four stations for the study area (Marigat and Mogotio Sub-Counties). Livestock production and marketing data used in analysis were obtained from the Ministry of Livestock and Fisheries Annual Reports (1999-2003). The data before 1999 was not available and after 2003 there was unavailable data for the rainfall that could match with livestock and marketing data to perform analysis. However, recorded livestock production and marketing data were unavailable and inconsistent and could not coincide with the available climatic data for a period of 30 years; some had huge data gaps and as such could not be used in the study. The field survey was carried out in the two Sub-Counties (Marigat and Mogotio) where 454 households were surveyed, ten Key Informants were interviewed and two Focus Group Discussions (FGDs) conducted.

1.7 Overview of methodological approach

The general methodological approach employed in the study was a mixed methods approach. Data on impacts of seasonal climate variability, weather forecasts, livestock production and marketing were sourced from the Ministry of Livestock and Fisheries annual reports and the field household survey through the use of key informant (KI) interviews, structured questionnaires and Focus Group Discussion (FDGs). A sample size of 437 was computed from the sample framework of households in the study area. The Global Position System (GPS) gadgets were used to establish the location of the household interviewed as well as KI and FDGs. ArcGIS 10.0 software was applied in the generation of a map showing the sites of the interview in the study area. Statistical analyses were carried out on the quantitative datasets. Content analysis was used on the qualitative datasets.

Long-term climatic data (observed precipitation) covering the period 1974 to 2003 was sourced from seven meteorological stations registered with Kenya Meteorological Department (KMD) within Baringo County. The data for maximum and minimum air temperatures was not available from the KMD and was, therefore, sourced from the CRU version TS3.22 (Climatic Research Unit at the University of East Anglia). These data were used to study the seasonal climate variability in the study area.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter covers the existing literature relevant to the study. It brings out, in a systematic manner, the scope to which the current problematic situation of an increasingly variable climate has been addressed by other researchers and what is already known about the research topic as a whole and the gap that still remains. This includes: climate variability and change in the drylands; the impact of seasonal climate variability on livestock production and marketing; indigenous seasonal weather forecasts; scientific (conventional) weather forecasts, and; integrating indigenous and conventional knowledge-based seasonal climate forecasts as a climate-risk management tool and livestock production and marketing in the ASAL.

2.2 Climate variability and change in the drylands

Drylands account for more than 40% of the world's land area and are home to over 2 billion people, 325 million of them in Africa, yet they are among the regions in the world where climate change impacts on ecosystems, livelihoods and human health are potentially the greatest (IPCC, 2014b). In Kenya's drylands, for example, more than 3 million pastoralist households are regularly hit by drought, costing the economy an estimated $12.1 billion in 2008 – 2011 (ILRI, 2014). Climate variability and change adds another layer of uncertainty and risk to the existing challenges faced by vulnerable households living in the drylands. Traditional coping mechanisms and emergency response measures are no longer sufficient to ensure recovery to productive livelihoods. The high variable is increasingly becoming a threat to human development in the drylands of East and Southern Africa (ESA). Climate variability and change leads to increases in the frequency and severity of droughts and floods and further increases the vulnerability and exposure of pastoralists and drylands farmers and their resources (land, water and livestock) to new risks. Since the climate is projected to continue changing, communities living and deriving livelihoods from drylands urgently need to enhance their climatic resilience (Nyasimi, 2014).

The problem of climate variability and its impact on food security in terms of agricultural productivity continues to attract scientific research in many parts of the tropics (Kasei et al., 2014). Climate change is inevitably resulting in changes in climate variability and in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events (IPCC 2012). The focus of the great majority of climate change impact studies is on changes in mean climate. In terms of climate model output, these changes are more robust than changes in climate variability (Thornton et al., 2014).

2.3 Impact of seasonal climate variability on livestock production and marketing

Thornton et al. (2014) reported that climate variability already has substantial impacts on biological systems and on the smallholders, communities and countries which depend on them. Some attempts are being made to use seasonal rainfall forecasts in the management of agricultural activities (Stewart and Hash, 1982; Sivakumar, 1988) whilst little attention is being paid to the within-season distribution of rainfall and its effects on crop growth, livestock and productivity (Kasei et al., 2014).

The seasonal distribution of rainfall is so important in determining vegetation and land use (McKeon, 2006). There is general agreement that changes in the frequency or intensity of extreme weather and climate events would have profound impacts on both human society and the natural environment. Recent years have seen several weather events causing large losses of life as well as a tremendous increase in economic losses from weather hazards (Easterling et al., 2000). An understanding of the net global impact of recent climate trends would help to anticipate impacts of future climate changes, as well as to more accurately assess recent technologically driven yield progress (Lobell and Field, 2007).

2.4 Indigenous knowledge seasonal weather forecasts

Nyong et al. (2007) point out that the African Sahel region is characterised by severe and frequent droughts with records dating back to centuries. The local population, through indigenous knowledge systems, have developed and implemented extensive mitigation and adaptation strategies which have enabled them to reduce their vulnerability to past climate variability and change. In support of Luseno et al. (2003) arguments, Odero (2011) found that indigenous seasonal weather predictions are the resource that is most readily available to smallholder farmers, pastoralists, fishing communities and forest dwellers in Kenya to address climate change challenges.

The indigenous knowledge seasonal weather forecasts encompass prediction of rainfall using local environmental indicators and astronomical factors. One important step in reducing the vulnerability of a climatic hazard is the development of an early warning system for the prediction or forecast of the event. There is a wealth of local traditional knowledge based on predicting weather and climate (Ajani et al., 2013). Chang‘a et al. (2010) reported that the local weather and climate are assessed and predicted by locally observed variables. It is enhanced by the experiences of the locals in using combinations of plant, animals and insects as well as meteorological and astronomical indicators. As stated by Kijazi et al. (2012), with reference to the conservation of the environment and addressing natural disasters, for a long time in history, local communities in different parts of the world have continued to rely on indigenous traditional knowledge. The communities, particularly those in droughts and floods prone areas, have generated a vast body of indigenous knowledge on disaster prevention and mitigation through early warning and preparedness (Roncoli et al., 2002; Anandaraja et al., 2008; Svotwa et al., 2007).

Luseno et al. (2003) argued that pastoralists worldwide rely heavily on indigenous seasonal weather prediction methods. They further stated that the climate information from indigenous sources is easily accessible and that the pastoralists have more confidence in this method. The formal forecasts, which are sourced from the meteorological stations, are less adopted (received) and believed. Eakin (1999) argued that it is important to appreciate the role that traditional weather forecasts play. Odero (2011) reported that knowledge held by local people, outside the formal scientific domain has been referred to as local knowledge or indigenous knowledge, or traditional knowledge. Ziervogel (2003) noted that the successful dissemination and adoption of climate predictions requires an in-depth profile of the characteristics and needs of user groups. Hammer et al. (2001) reports that efforts are currently being directed towards improving the skill and distribution of formal and indigenous seasonal weather predictions.

2.5 Scientific (conventional) weather forecast

Climate information has increasingly become important and available in the last decade and Regional Climate Outlook Forums have enhanced dialogue on seasonal forecasts among producers of information, researchers and different categories of decision-makers (Goddard et al., 2010). Jiri (2016) pointed out that scientific forecasts have to some extent failed to make the intended impact on smallholder farmers due to the inaccessibility and inequitable distribution of this information to smallholder farmers as the primary users of the information. Further, Jiri (2016) argued that in the context of the dominance of scientific forms of forecasting, the architects of this approach expressed unfairness to indigenous indicators, which they tend to regard as backward.

Scientific forecasting information is not embraced by the smallholder farmers due to a number of reasons. Lack of a sense of ownership by farmers and decision makers has contributed to the limited uptake of the disseminated meteorological information (Glantz 2005; Goddard et al., 2010). For this and other reasons, climate scientists are increasingly under pressure to transcend their disciplinary confines and engage in a process of joint, continued and participatory learning with users of the information and encourage effective outreach programmes for the information to realize its full potential. It corroborates Koigi (2016) report, that as changes in weather continue to ravage farms and take a toll on food production across East Africa, scientists and meteorologists are turning to traditional rainmakers and weather forecasters to bolster the accuracy of weather predictions.

2.6 Integrating indigenous and scientific knowledge-based climate forecast

The planning of agricultural activities and other seasonal livelihoods depends on the performance of rains which are characterised by the onset and cessation dates, intensity, frequency and distribution of wet and dry spells and amounts (GOK, 2014a). The seasonal rainfall advisories for Baringo's Sub-Counties are based on a participatory scenario planning (PSP) approach to making weather and climate forecast accessible to all the users and the general public through "barazas" and other media. The approach involves holding a PSP workshop before the commencement of every season. The PSP workshop brings on board participants from the private and public sector and those with Indigenous Technical Knowledge. All forecasters including Indigenous Technical Knowledge Forecasts (ITF) and Seasonal Climate Forecasts (SCF) by the KMD endeavour to give accurate and timely information (ASDSP, 2015).

Kolawole et al. (2014) recommended that indigenous traditional knowledge on weather scenarios, enhanced by further research and scientific knowledge need, to be integrated for better decision making. Further, Kolawole et al. (2014) pointed out that, farmers and scientists need to agree on local indicators (weather predictors), which in their present forms, vary in interpretations from one locality to the other. Integration of these two knowledge systems may also correct the seemingly wrong perceptions of some stakeholders (e.g. policy-makers, politicians, academics/scientists, etc.) that local knowledge is not well positioned to handle complex contemporary problems of an ever-changing environment. In support, Chang'a et al.

(2010) reported that integration of indigenous knowledge into conventional weather forecasting system is recommended as one of the strategies that could help to improve the accuracy of seasonal rainfall forecasts under a changing climate.

2.7 Seasonal weather forecast information as a climate risk management tool

Climate information can help farmers and pastoralists manage their crops and livestock to minimize climate risks and maximize opportunities (IDRC, 2010). The surveys and pilot studies in Eastern and Southern Africa show that farmers see opportunities to benefit from seasonal forecasts (Cooper et al., 2008). Such kinds of studies have also shown that farmers are often constrained by the timing, scale, and format of the available forecasts, lack of trust and comprehension of the forecasts, and the need for competent guidance for livelihood responses as a requirement for rural communities to use seasonal forecast effectively (O'Brien et al., 2000; Ngugi, 2002; Patt and Gwata, 2002; Rao and Okwach, 2005).

Ziervogel (2003) stated that seasonal weather forecasts have been promoted to increase the resilience of marginal groups in Africa. Also, Sivakumar et al. (2000) reported that seasonal weather forecasts could help farmers decide what type of crops to plant and which livestock husbandry practices to embrace, the types of livestock to sell and when, what precautionary measures to take, and whether to diversify or not, and in so doing could avoid undue risks. Hammer et al. (2001) reported that agricultural systems are notoriously responsive to climate fluctuations. Particular attention is being given to understanding what potential there is for using seasonal weather prediction to address climate-related risks and at the same time create new opportunities for reducing poverty and vulnerability among the rural poor. Efforts are currently being directed towards improving the skills and dissemination of both formal and indigenous seasonal weather forecasts.

2.8 Livestock production and marketing in the ASAL

As outlined by Barrett et al. (2001) livestock serves as a store of wealth, a form of insurance against risk, an important status symbol, a means for securing access to land, and an instrument for establishing social relations, including marriage. The vast majority of ASAL pastoral wealth is in the form of livestock (Little, 1992; Coppock, 1994; Amanor, 1995; Desta, 1999; McPeak and Barrett, 2001).

According to Ariza-Nino et al. (1980) livestock markets can easily be differentiated by the type of sellers and buyers operating in the market and the purpose for which livestock are purchased. In some years seasonality is more pronounced than in others but it is something markets expect; something in the back of the mind of each trader (see Table 2.1)

Table 2.1: Characteristics of livestock markets

Type of market	Main sellers	Main buyers	Purpose of purchase
1. Primary collection Markets	Producers	Other producers	For stock replacement or fattening
		Local butchers	Slaughter
		Traders	Collection for resale in larger regional markets
		Local community	Social cultural ceremonies
2. Secondary distribution Markets	Traders	Local butchers	Slaughter
		Traders	For resale in terminal markets
3. Terminal markets	Traders	Local slaughter houses	Slaughter
		Traders	Export

Source: Ariza-Nino et al. (1980), Modified

Bekure and Tilahun (1982) pointed out that the efficiency of the market is reflected by the marketing costs of the system and the extent to which price changes are transmitted through the marketing system. These two aspects strongly influence the operation of the markets. Further, Bekure and Tilahun (1982) argued that in most African countries there is a severe paucity/scarcity of time series data on livestock prices as well as on the performance and efficiency of the livestock marketing system. In many instances, policy decisions on livestock marketing are taken in the absence of vital information on how they affect livestock producers, traders, slaughterhouses, butchers and consumers. The absence of data on the magnitude and seasonality of supply as well as prices can frustrate the success of development projects. A case in point is the closure of the meat packing plant at Kotsi in Sudan after a few months of operation (Bekure, 1983). For any livestock system, marketing is an important aspect. It provides the mechanism whereby producers exchange their livestock and livestock products for cash. The cash is used for acquiring goods and services which they do not produce themselves, in order to satisfy a variety of needs and wants ranging from food items, clothing, medication and schooling to the purchase of breeding stock and other production inputs and supplies. Time series data on prices pastoralists are paid for their livestock and livestock products, as well as prices they pay for inputs, are essential for such analysis (Bekure and Tilahum, 1982).

Enkono et al. (2013) observed that market outlets that are available to cattle producers in developing areas include private sales, auctions, butcheries, abattoirs, and speculators. Moreover, small-scale cattle farmers are faced with a number of challenges: Bahta and Bauer (2007) identified lack of market access, poor access to market information, poor infrastructure in rural areas, and low level of tacit knowledge. Musemwa et al. (2008) pointed out that cattle farmers in the communal areas fail to attract buyers in their community due lack of marketable numbers and poor conditions of livestock. Furthermore, Musemwa et al. (2008) stated that group marketing, decentralization of cattle information centres and the involvement of small-scale farmers in the dissemination of information plays a vital role in improving farmers' access to formal markets.

Habtamu et al. (2015) reported that livestock marketing in the ASAL is complicated by high transaction costs due to the long distances that pastoralists must travel and the poor infrastructure that is generally found in the marketplace. Further, Habtamu et al. (2015) argued that marketing institutions in the ASAL are often poor and are not suited for procuring gain from livestock sales during a crisis. The major challenging problems of pastoralists include low productivity, lack of sustainable credit provision, lack of fair market for their livestock, drought, and very poor saving culture. As a result, pastoralists in the ASAL face crucial problems at times of drought due to the shortage of food and death of livestock.

Mutsotso et al. (2014) pointed out that the Government of Kenya (GOK) recognises that Baringo County is semi-arid and livelihood is largely dependent on livestock. Further, Aklilu et al. (2002) acknowledged that this fact prompted the government to intervene through off-takes, destocking/restocking, supplementary livestock feeding, cross border peace initiatives emergency veterinary programme and transport subsidies. Further, Mutsotso et al. (2014) reported that low-quality livestock, high mortality rates, persistent livestock rustling, and perennial and prolonged droughts affect many livestock keepers in the

County. Limited markets for livestock significantly contribute to the rising levels of poverty. In view of this fact, the government initiated the famous Kimalel Goat Auction (KGA) in Marigat Division in the mid-1980s. The KGA took on the goat identity since it was the principal livestock type constituting over 95% of all the livestock sold. Serem (1994) reported that the primary form of organized marketing of livestock in the proposed study area is through auctions. Serem (1994) further documented that most of the auctions have relatively low buyers' concentration and, therefore, little competition. Also, Relief Web (2013) noted that while there are existing livestock facilities in the County that support livestock production and marketing (Table 2.2), the services are not adequate for the livestock population.

Table 2.2: Available livestock infrastructure in Baringo County

Livestock infrastructure	Available number
Sales yards	10
Abattoirs	36
Vaccination and animal handling crushes	17
Holding grounds	2
Dips	49

Source: Relief web report (2013)

Hatfield and Davies (2006) stated that pastoral systems are more than merely a model of livestock production. They are also consumption systems that support 100-200 million mobile pastoralists globally. Osterloh et al. (2003) found that pastoralists in East Africa's arid and semi-arid lands regularly confront climate shocks. This scenario plunges them into massive herd die-off and eventually the loss of wealth. Further, Osterloh et al. (2003) argued that one of the most puzzling features of pastoralists' behaviour in times of stress has been their relatively small and non-response rate of marketed off-take of animals when faced with likely losses to herd mortality. LLP (2010) reported that livestock-based livelihoods in the drylands of Africa are vulnerable to climate change and thus liable to be affected. In other parts of the world, livestock is increasingly seen as a driver to climate change rather than being affected by it. This notion is supported by Bailey et al. (2014) who documented that human consumption of meat and dairy products is a major driver of climate change. Further, Bailey et al. (2014) reported that the greenhouse gas (GHS) emission associated with their production accounts for over 14.5% of the global total; this is more than the emission produced from powering all the worlds' road vehicles, trains, ships and airplanes combined.

Figure 2.1 below shows a schematic representation of a livestock marketing system model.

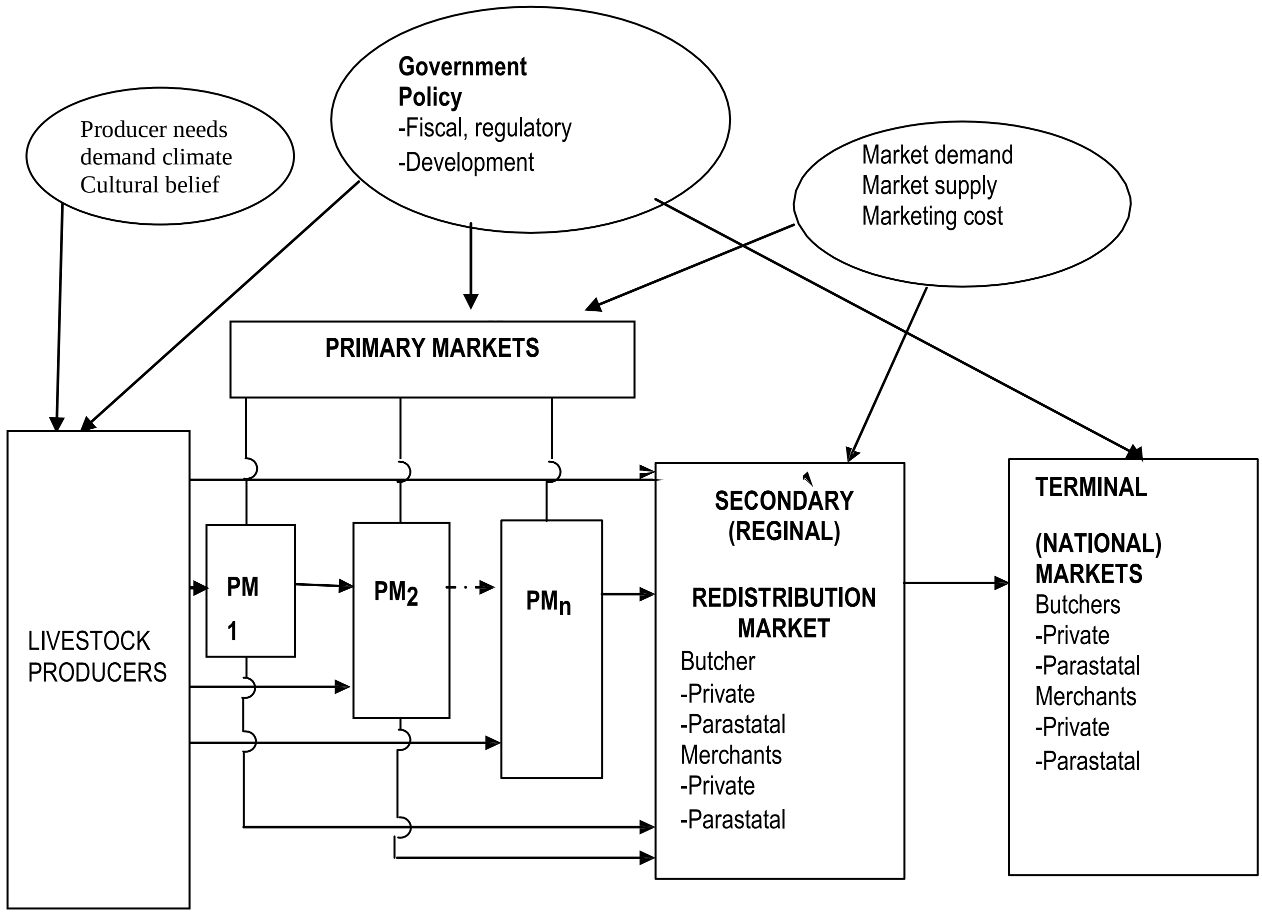


Figure 2.1 Schematic representation of a livestock marketing system model (adopted modified and from Bekure and Tilahun 1982)

Figure 2.1 above demonstrates a livestock marketing system model. It exemplifies that the livestock producers demand climate information in order to have livestock to supply to the primary, secondary and terminal markets. This demand for climate information will have an influence on the number and quality of livestock the producer supplies to the market. The government policy influences, the supply and demand in terms of the levies imposed on the buyers and sellers in the market. However, demand and supply forces determine the prices of the livestock in the market. The market cost is also a prudent element cost in pricing if the livestock producer intends to get profit out of his produce in the market.

CHAPTER THREE: STUDY AREA AND METHODS

3.1 Introduction

This chapter describes the study area, data and the methods used in addressing the research objectives and questions. It starts with a description of Mogotio and Marigat/Baringo South Sub-counties which comprise the study area in Baringo County, Kenya. This is followed by the description of the location of Baringo County, narrowed down to Mogotio and Baringo South Sub-counties in terms of biophysical and socio-economic settings. It also describes the conceptual framework (CF) and the mixed methods approach used in the study including desktop studies, field work and data analysis for each objective. Lastly, it describes the data synthesis to address the overall/broad objective of the study.

3.2 Study area location and description

The study area is Baringo South and Mogotio Sub-counties. The two sub-counties are among the six sub-counties that comprise Baringo County. They share some similarities in relation to agricultural ecological zones and livelihoods. Most of Baringo Sub-county is located in Agricultural Ecological Zone[1] (AEZ) five while Mogotio is in four. The residents in the two counties practice pastoralism and agro-pastoralism.

a) Baringo Sub-County

Baringo South-County is the former Marigat District (see Figure 1). It comprises of four administrative wards which include; Mochongoi, Ilchamus, Mukutani and Marigat. It has a population of 80,871 (IEBC, 2009) and an area of 1,985 km^2. This Sub-county has the biggest number of irrigation schemes in the County. The Sub-county has a large population of cattle sheep and goats (see Table 3.1).

Table 3.1: Livestock population in Baringo South and Mogotio Sub-County

Species of livestock	**Population (Numbers)**	
	Baringo South	Mogotio
Cattle	63,900	136,454
Sheep and Goats	234,973	282,322

Source: GOK (2013d)

[1] **Agricultural Ecological Zoning** involves the inventory, characterization and classification of the physical environmental resources which are meaningful for assessment of the potential of agricultural production systems. The physical resources include components of climate, soils, and land form, basic supply of water, energy nutrients and physical support (Sombroek et al.,1982)

Despite having irrigation schemes, they continue livestock production as it is a cultural attribute. The livestock marketing yards are designated and located at Marigat, Kiserian, Mukutani, Koriema, Maoi Kapindasim, Kabel (Mochongoi) and Marigat slaughter slab. The markets operate on different days and hold different species of livestock, although some currently are not operational because of insecurity and poor management (see Figure 3.1).

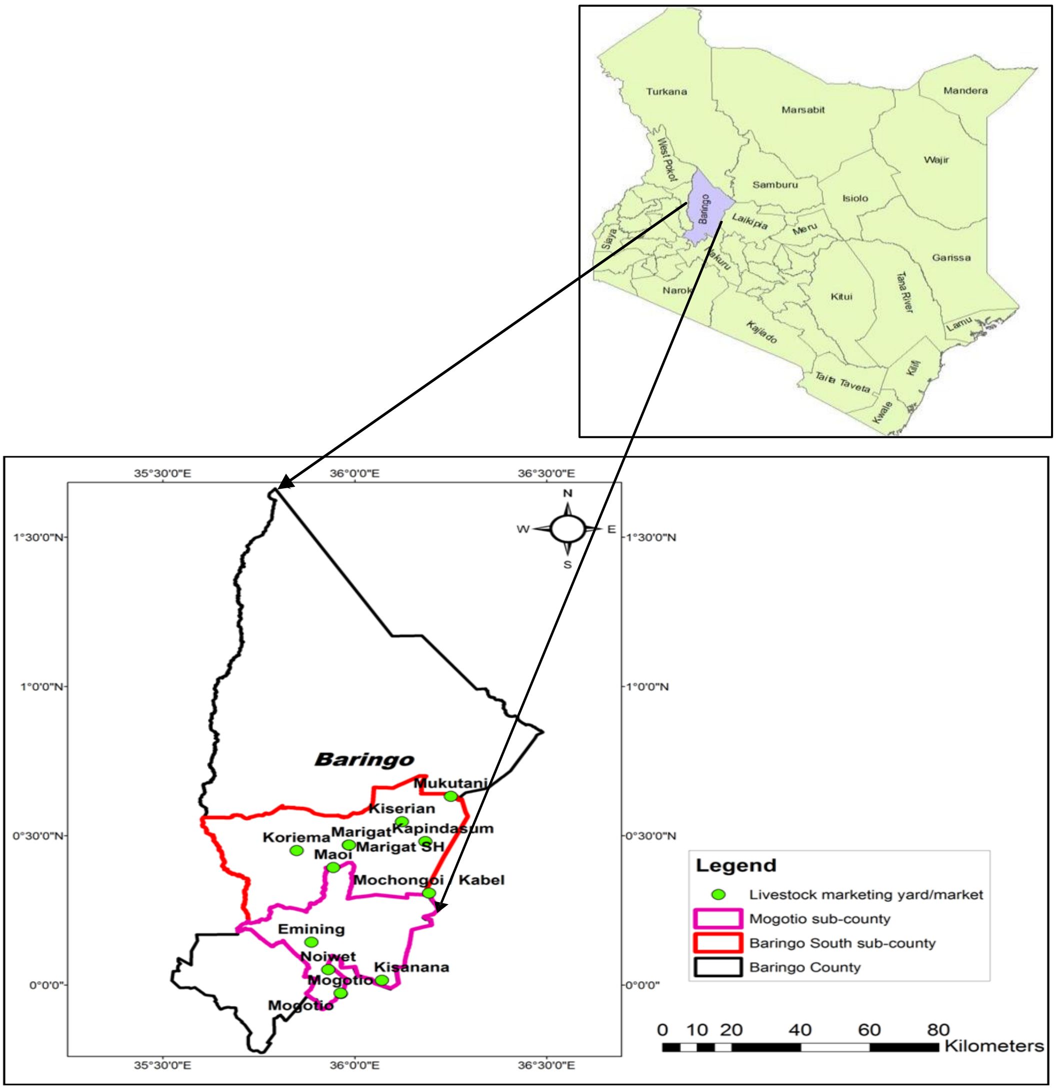


Figure 3.1: Map of Kenya and the study area location, Baringo County. Mogotio and Baringo South are shown with the centers of interest where livestock markets and slaughter houses are situated

b) Mogotio Sub-County

Mogotio Sub-County was delineated from the former Koibatek District and achieved the sub-county status in 2009. It borders Baringo South (Marigat) and Baringo Central to the west, Rongai and Nakuru North sub-counties (both of which are in Nakuru County) to the south and east, respectively, and Koibatek (Eldama Ravine) Sub-County to the north. The equator traverses the southern part of the sub-county. Mogotio Sub-County covers an area of 1314.7 km^2 and has a human population of 61,699 (IEBC, 2009). The average population density is 48 persons per km^2 (GOK, 2013e). It has a large livestock population of cattle, sheep and goats (see Table 3.1). The residents rely on livestock production for their livelihood.

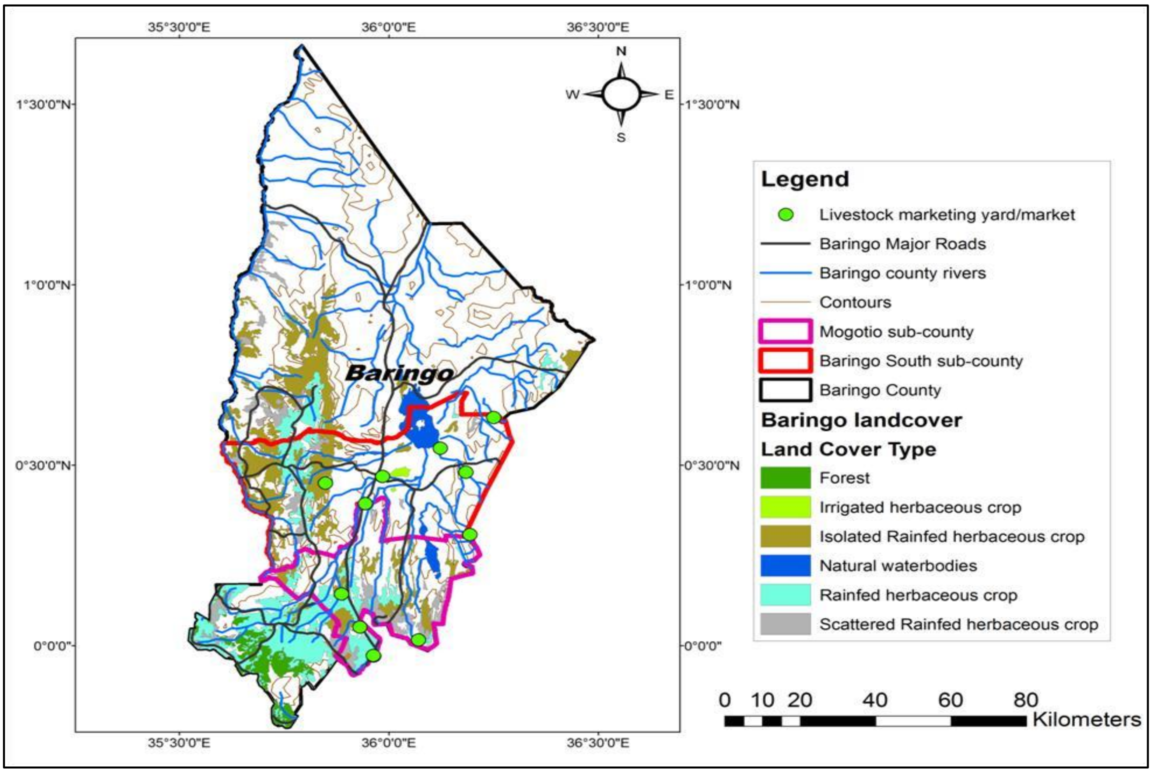


Figure 3.2: Topographic map of Baringo County with livestock marketing yards

3.3 Biophysical setting

3.3.1 Climate

In Baringo South-Sub-County, the rainfall is erratic and not reliable with high variability, receiving an average rainfall of 500mm per annum (Wasonga et al., 2011). This climate variability significantly affects the settlement patterns and economic activities in the Sub-County. According to GOK (2013b), in ordinary circumstances, rainfall is bimodal with long rains running from March to July while short rains run from the end of September to early

November. The average annual temperature is about 27°C. The period between January and March is the hottest. Mogotio Sub-County average annual rainfall totals were 654mm with weak bimodal peaks recorded from March to May and June to August. The mean annual temperatures, maximum and minimum, are 32.4°C and 16.8 °C, respectively (GOK, 2013f).

The study area has been experiencing an oscillating trend in rainfall with significant peaks being observed in 1977, 1988-89, 1997-98 and 2007 (see Figure 3.3). These are the four major peaks with the highest amounts of rainfall over the last four decades. It is worth noting that the area has been receiving hefty rainfall in every ten years over the 1971-2010 period (Lelenguyah, 2013). This observation tends to concur with United Nations Development Programmes' (UNDP) climate change profile for Kenya, which notes that rainfall observations since 1960 have not shown any statistically significant difference county wide (McSweeny et al., n.d.). The respondents in Lelenguyah (2013) study perceived that heavy rain events had continued to occur in the area since 2002 when excessively heavy floods occurred.

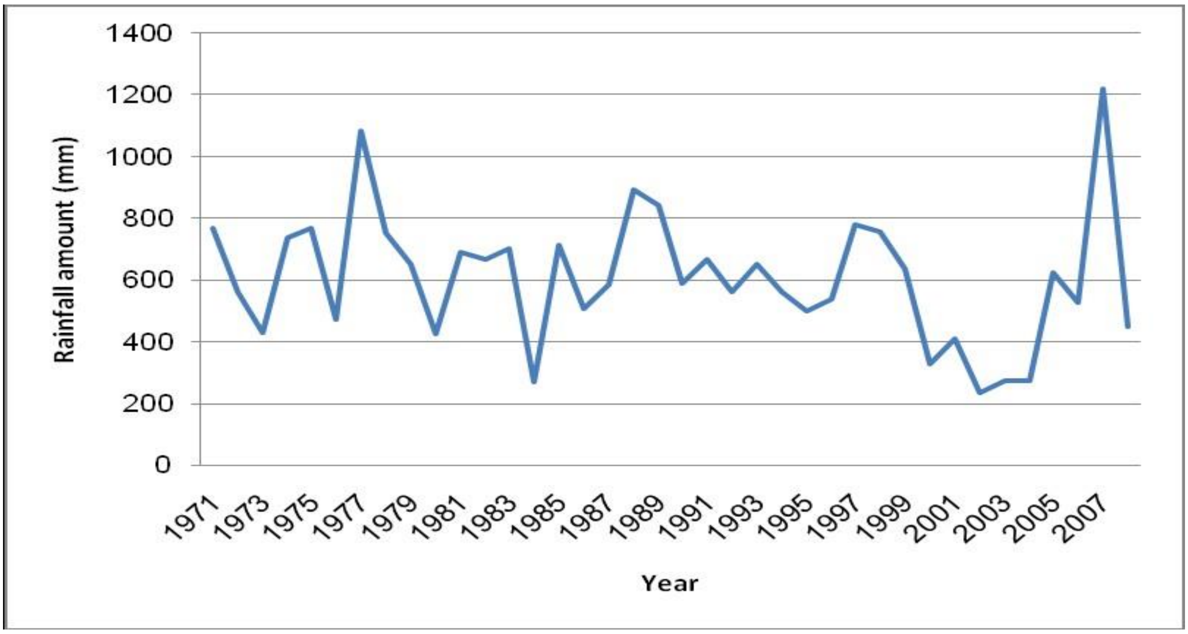


Figure 3.3: Trend of rainfall in Baringo South Sub-County over the period (1971-2007)
Source: Lelenguyah (2013)

3.3.2 Vegetation

3.3.3 Soils, land uses and resources

Table 3.2 below shows agro-climatic zones in Kenya ranging from I to VII. They are classified in a scale of five: humid, sub-humid, semi-humid, semi-arid arid and very arid. The highest moisture index is at agro-climatic zone I with more than 80% and the lowest is VII with less than 15%. The highest annual rainfall (1100-2200mm) is observed in zone 1 and the lowest (150-350mm) at zone VII. The largest land area proposition is covered by zone VII at 46%.

Table 3.2: Moisture availability zones in study area with rainfall and land proportions

Agro-climatic Zone	Classification	Moisture Index (%)	Annual Rainfall (mm)	Land area (%)
1	Humid	>80	1100-2200	
11	Sub-humid	65-80	1000-1600	12
111	Semi-humid	50-65	800-1400	
IV	Semi-humid to Semi-humid	40-50	600-1100	5
V	Semi-arid	25-40	450-900	15
VI	Arid	15-25	300-550	22
VII	Very arid	<15	150-350	46

Source: Modified from Sombroek et al. (1982)

As cited by Orodho (2006), Sombroek et al. (1982) reported that climate, vegetation and land use potential have been used to assess land suitability for different purposes. Kenya is divided into seven agro-climatic zones using moisture index based on annual rainfall expressed as a percentage of potential evaporation (see Table 3.2). Natural vegetation is characteristic of agro-ecological zone V1, and V (Government of Kenya, 2013). There are drylands acacia trees mainly *Acacia tortillis, Acacia nubica, Boscia abyssinica*. Also, *Balanites aegyptiaca*, and bushes of *Salvadora persica* are present. The bare ground springs up with life of ephemeral herbs when it rains. The vegetation gradually gives way to bushed savanna grassland towards the uplands in the east, west and south (see Figure 3.2). The savanna becomes sparse with increasing aridity towards the North from Nginyang (914m a.s.l) to Kapedo (762m a.s.l).

Johansson and Svensson (2002) described the soils in Mogotio and Baringo Sub-Counties as mainly colluvial derived from Tertiary volcanic basalt rocks underlying volcanic and pyroclastic rock sediments weathered and eroded downslope from the uplands. They are classified as eutric to calcific to vertic fluvisols of sodic to saline phase. They are imperfectly drained to well drained, extremely thick, dark brown, hard to friable sandy and silty clay loams. They are of high fertility with ample supplies of Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg) but with small quantities of Nitrogen (N) and Carbon (C). They are slightly acidic to alkaline.

According to GOK (2013b) land in the study area has drastically reduced in terms of the size of land owned by an individual. This scenario has reduced productivity and the efficiency in the production, rendering people susceptible to food insecurity. Change in land use has been from pastoral to agro-pastoral.

3.3.4 Physiography and drainage

The study area is on the floor of the Rift Valley, on a flat colluvial plain bordered by Laikipia escarpment to the east and Tugen hills to the west. The plain is covered mainly by lacustrine salt, impregnated silts and deposits. Lake Baringo is 20km to the north, and a similar distance to the south is Lake Bogoria, which is next to Lake Ninety-Four. To the north of Lake Baringo are several extinct volcanoes, for example in Tiati, Paka, Kamogo and Korosi areas. Both the escarpment and the hills are irregularly dissected by seasonal and a few permanent rivers running downslope into the only three surface water masses of Lakes Baringo, Bogoria and Ninety-Four. River Perkerra, with its watershed in southern parts of the Tugen Hills, is a permanent river passing through Marigat town and is depended upon by Perkerra Irrigation Scheme for irrigation purposes. River Molo is another river flowing into Lake Baringo while River Waseges is the major river feeding Lake Bogoria. (GOK, 2013f)

3.3.5 Water resources

The three lakes, namely; Baringo, Ninety-four and Bogoria, provide attraction to tourists and local fishing in Lake Baringo (GOK, 2013b). Lake Ninety-Four is a new lake which formed in 1994. It is the smallest in size relative to the other two. There are quite a number of rivers, springs and ground water sources, but the majority of all these sources do not have a good quality and sufficient quantity to serve domestic and commerce uses. Most of them are saline, polluted or silted.

In Mogotio Sub-County the primary water sources are two major rivers, Perkerra and Molok. There are 31 productive boreholes, and 102 water pans. Most of the springs are in Kimngorom and Sirwa areas within the Sub-County. A few individuals and institutions have installed water harvesting facilities in their premises (GOK, 2013f).

3.3.6 Biophysical vulnerabilities

According to GOK (2013f) there is clear evidence of massive land degradation partly due to charcoal production, with large number of charcoal bags displayed along the roads in the area. Shortage of pastures and water for livestock are significant challenges which are linked to climate change and variability. The vulnerability of the Baringo people to food and nutrition insecurity is as a result of poverty. It is also aggravated by the degradation of the natural environment and the products (e.g. fruits, water and the range-fed livestock) that it provides.

GOK (2013d) highlighted that, to counteract the challenge of shortage of pasture and water, pastoralists in the study area have been undertaking the current practice of establishing livestock feed resource banks. They reserve the swampy area around Lake Baringo and Bogoria for dry season grazing. It is not adequate due to the large population of livestock (see Table 3.1). At the same time, some of the pastoral communities that reside in these areas have turned to agro-pastoralism due to the erratic rainfall in an attempt to adjust to the climate variability and change. Several others adaptation options, namely; livestock off-take and livestock refuge, are currently being undertaken to address the adverse effects of climate change and variability but still they have their drawbacks.

3.4 Socio-economic setting

In the County, the rapidly growing populations in the vulnerable semi-arid areas have led to exerted pressure on the land. It has resulted in severely degraded land, soil erosion and sedimentation of open water bodies (Johansson and Svensson, 2002). The report from Office of the Controller of Budget, Baringo County, revealed that game park fees are the highest contributor at 49 percent, of all the revenue sources. The animal stock sales are the lowest with four percent (GOK, 2014b). This information shows a gap that needs to be addressed since livestock is the primary source of income for the pastoral communities in the study area.

3.4.1 Political and administrative context

Since both sub-counties are in the larger Baringo County, the political leadership, including the Governor is affiliated with (United Republic Party) URP (Jubilee) party and a few affiliated with Kenya African National Union (KANU) party at the time of the survey. Mogotio Sub-County has one constituency, unlike Baringo South. In Mogotio, there are four County Assembly representatives and five divisions, 23 locations and 53 sub-locations as administrative units. Two structures govern the area; national and county. The former at Sub-County level is headed by a Deputy Commissioner, at the division level by an Assistant County Commissioner, at the location level by a Chief and eventually at sub-location level by an Assistant Chief. A Sub-County Administrator heads the Sub-County. The Ward is led by a Ward Administrator and villages are governed by Village Administrator's. The urban areas are manned by a Town Administrator or Municipal Manager.

3.4.2 Local economic setting

In Baringo South and Mogotio Sub-counties, semi-nomadic livestock rearing is the main economic activity of the community though there is an increasing interest in crop production to augment the family food supply. The rangelands on which the livestock and the community depend on are denuded and severely eroded. In many years the region has been unable to support the livestock population adequately; thus, the existing livestock population is unable to meet the full subsistence needs of the people (GOK, 2013b). The situation has in the recent past been exacerbated by the invasion of the tree species *Prosopis juliflora.* It is an exotic tree/shrub that was introduced as a conservation measure to roll back land degradation (Mwangi and Swallow, 2005). This scenario has posed shortage of pasture to the livestock. The plant has ability to suppress all the pasture due to its invasive ability. Also, it has been reported to have injured the sheep and goats with its sharp thorns which also destroy the teeth of the same animals (Abdulahi et al., 2017).

The area is characterized by a few wealthy households controlling the highest percentage of resources. In areas with irrigation schemes, more affluent families have access to the large plots. The agricultural sector is the backbone of the County's economy; hence the Baringo County Integrated Development Plan (2013-2017) targeted this study area (GOK, 2013b).

3.4.3 Social setting

The Mogotio and Baringo sub-counties are rich in culture. Most people are Christians, although there are a small number of residents who still adhere to traditional beliefs. The cultural beliefs and traditional practices such as Female Genital Mutilation (FGM), early marriage and cattle rustling have contributed to slow growth of the County's economic development. Modern Christian denominations in Baringo include the African Inland Church (AIC), Roman Catholic and the Anglican Church of Kenya (ACK).

Livestock, especially cattle, is an important feature of the Baringo culture. It is an important source of wealth. It serves as a form of traditional currency used to negotiate for wives and dowry payment. Majority of the residents of the study area are Kalenjin, and traditionally men are responsible for looking after livestock and protecting their family from external aggressors. Women are tasked with taking care of children, working in the farm and performing domestic duties such as cooking and fetching water. Children usually look after goats and sheep, but in the modern lifestyle, most of them attend school and have attained formal education.

The two primary designated trading centers are Marigat and Mogotio in Baringo south and Mogotio sub-county, respectively. In both sub-counties, communities can access health services for both their livestock and human needs. They are also able to access agricultural inputs from agro-traders. The banks, public transport terminals, abattoirs and livestock marketing yards are also located in the centres. From the same centres, they access the Sub-County administrative headquarters services.

3.5.4 Health setting

In Baringo South and Mogotio sub-counties, for the past five years (2008-2012) there has been a prevalence of malaria, typhoid and tuberculosis, despite the acute awareness and preventive measures undertaken by the Ministry of Health. Lives have been lost with respect to these diseases. Other illnesses such as Hepatitis B and C have become rampant in the region (GOK, 2013d). The HIV/AIDS pandemic remains a fundamental challenge although efforts have been stepped up to reduce the prevalence rate (GOK, 2013d).

The mandate of the Department of Veterinary Service is to control animal diseases and pests (GOK, 2010). Also, it works to increase livestock productivity and ensure high-quality livestock and their products and facilitate trade. Munyua et al. (2010) reported that the 2006/2007 Rift Valley Fever (RVF) outbreak was the first to be experienced in this area over the study period (1971-2010). Lelenguyah (2013) note that there is a significant relationship between rainfall amount and (RVF) outbreak in the study area; outbreak have been contained through veterinary intervention (vaccination) and a drop in the amount of rainfall and flooding.

3.4.5 Institutional framework

Two departments govern the livestock industry in Baringo south and Mogotio sub-counties: the Livestock Production Department and the Veterinary Service Department. GOK (2010) pointed out that the mandate of the Department of the Veterinary Service Chapter (2010-2011) is to control animal diseases, pests and increase livestock productivity. Also, it ensures high quality livestock and their products and facilitates livestock trade. The department provides a regulatory service role in surveillance, reporting and control of disease and pest. It further regulates animal movement and quarantine, as well as issue of sanitary certificates for livestock and their products. It also provides inspectorate services, control of zoonoses, and delivery of artificial insemination services. Through working together with the stakeholders/partners such as local authorities and law enforcement agencies, the Veterinary Department regulates the livestock market wherever there is a disease outbreak, and all the abattoirs.

3.4.6 Socio-economic vulnerabilities

As described in section 3.2.6, the study area has been experiencing a lot of degradation related to human activities and climate change and variability. This has adversely affected livestock production which is the primary livelihood of the communities living in the study area. Unfortunately, the livestock sale holds the lowest position in the contribution of County revenue. Mwangi and Swallow (2005) reported that an effort to conserve the environment was addressed by planting *Prosopis juliflora* in 1980, but it has turned to be a menace. The *Prosopis juliflora* pods have been reported to result in facial contortions, impacted rumen and constipation among livestock. These ill effects may sometimes result in death. Its leaves contain various chemicals known to affect palatability to livestock but also suppress the germination and growth of crops, weeds and other trees. The plant is very invasive, and it has suppressed pasture and invaded the land where crops, could grow, contributing to food insecurity. It has also affected the road infrastructure by encroaching most of the roads in the study area, making the roads impassable.

3.5 Conceptual framework

Figure 3.4 below demonstrates the research problem and how the study has attempted to address it sequentially.

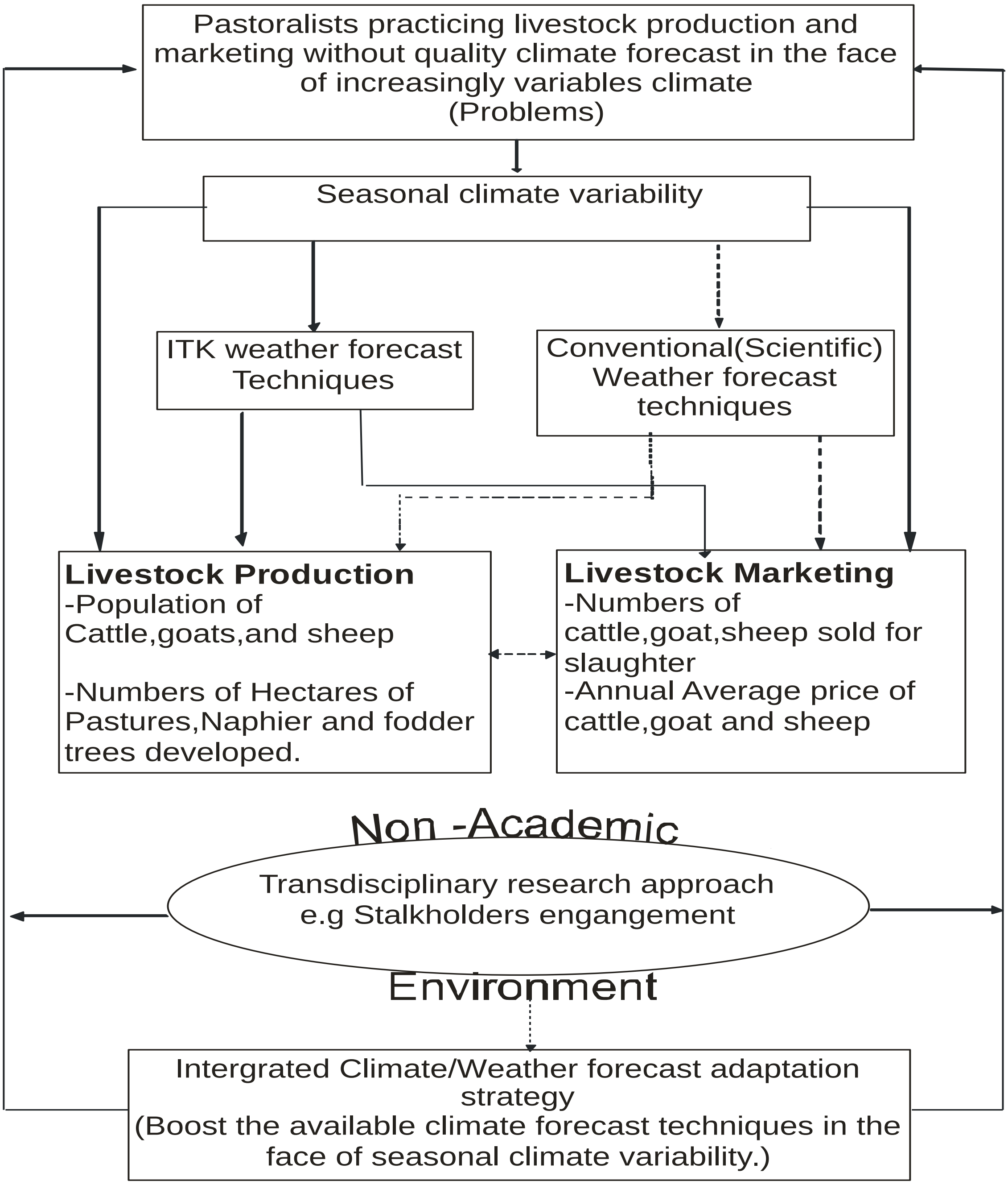


Figure 3.4: Conceptual framework
Source: Author, 2017

The conceptual framework (CF) shows that the seasonal climate variability has impact on the livestock production and marketing. This suggests that there is perhaps a strong relationship among the three above-mentioned variables (seasonal climate variability, livestock production and livestock marketing).

The CF also hypotheses that the communities in the study area are using seasonal weather forecast information from indigenous and conventional sources in addressing climate risks related with seasonal climate variability. Based on the reviewed literature the former source is preferred and its reliability has been tested for a long time unlike the latter where only a few of the community members trust it. This suggests that there is a likely relationship between indigenous weather forecast and the impact it has on the livestock production and marketing. This demonstrates weak relationship among the three variables (seasonal climate variability, conventional weather forecast and livestock production and marketing). This weak relationship is evidenced by the available literature on the utilization of climate/weather information from conventional source to enhance livestock production and marketing in the study area. In generating and developing the appropriate adaptation strategy to address the current situation a TD approach is embraced where the stakeholders' engagement is nurtured within a non-academic environment and interventions are recommended.

In the CF, the indigenous and convectional/scientific seasonal weather forecasts are blended (integrated), with the supposition that pastoralists can manage climate related risks on livestock production and marketing by using blended seasonal weather forecast information. If a blended forecast approach is taken up by pastoralist in the study area, it is expected that there will be a positive impact on livestock production. Also, on the marketing side, an increased sale in number of cattle/sheep/goats, as well as revival of marketing yards and abattoirs will be realised.

3.6 Methods

3.6.1 Objective 1: Impacts of climate variability on livestock production and marketing

3.6.1.1 Desktop studies and secondary data collection

Literature related to impacts of seasonal climate variability on livestock production and marketing was reviewed. Further a review on the appropriate method of measuring precipitation experienced in an area was undertaken.

a) Livestock production and marketing data

The secondary data on livestock production and marketing covered the five years 1999-2003, this being the only period for which a consistent and continuous data set was available. The livestock data comprised: population of livestock species (cattle, goats and sheep) and number of hectares of fodders and pasture developed. Market data included: quantity of animals sold for slaughter and annual average prices of livestock species sold for slaughter. The above-mentioned dataset was collected from the former District Ministry of Livestock and Fisheries annual reports, livestock marketing co-operatives, and other reports from the former Baringo which comprised the Baringo County.

b) Climate data

The 30 years climate data comprised monthly observed precipitation and gridded daily air maximum and minimum temperatures, sourced from Kenya Meteorological Department (KMD). This data was drawn from a total of seven meteorological stations within Baringo County. Three of the stations were within the study area (Mogotio and Marigat sub-counties), namely; Perkerra Agricultural Research Station, Snake Farm-lake Baringo, and Lake Bogoria National Reserve. The other four were within Baringo County but outside the study area. These were Chemususu Forest Station, Kimose Agricultural Holdings Ground, Talai Agricultural Station and Kibimoi Agricultural Holding.

Gridded daily air maximum and minimum temperatures data were collected for the following stations: Snake Farm-Lake Baringo, Kibimoi Agricultural Holding, Talai Agricultural Station, Lake Bogoria, Perkerra Agricultural Research Station, Chemususu Forest Station and Kimose Agricultural Holding Ground. The thirty years' period for the air temperature data ranged from 1980 to 2008. The monthly gridded data was sourced from the Climate Research Unit (CRU); the data is gauge-based, gridded at 0.5° by 0.5° resolution. The CRU TS series of data sets (CRU TS = Climatic Research Unit Time series) contain monthly time series of precipitation, daily maximum and minimum temperatures, cloud cover, and other variables covering Earth's land areas for 1901-2015 (CRU TS4.0 is a recent release). The data set is gridded to 0.5x0.5 degree resolution, based on analysis of over 4000 individual weather station records. The CRU version TS3.22 data is described by Harris et al (2014). The link for the data is https://crudata.uea.ac.uk/cru/data/temperature/#datdow

3.6.1.2 Data Analysis

a) Rainfall station data

According to Zahumenský (2004) the primary purpose of quality control of observational data (Einfalt et al., 2008) is missing data detection, error detection and possible error corrections in order to ensure the highest possible reasonable standard of accuracy for the optimum use of these data by all possible users. The percentage of missing rainfall data in the above-mentioned weather stations was less than 10% and the data spread over 20 years, hence met the requirements of World Meteorological Organization with regard to climatological analysis. Radi et al. (2015) recommended imputation approaches to fill in missing rainfall data. For this study the multiple imputations method was used to overcome underestimation of standard errors and confidence intervals typical of single imputation. The method involved estimation of missing rainfall data from the observations of rainfall (rainfall data sets) at the same station and period but different years and filling in of the missing data with substituted values. The imputed data sets were combined and average worked out. According to Ochieng et al. (2017) the missing rainfall data *Px* was estimated using the following formula:

$$Px = 1/n \sum_{i-0}^{i-n} Pi \qquad \text{Equation (1)}$$

Where:

n = the number of rainfall data sets

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

Px = missing rainfall data

Microsoft Excel was used in analysing the long term observed precipitation data to generate Baringo County trends for 30 years. Linear regression analysis was used to establish the relationship between the mean areal precipitations, annual averages of observed precipitation and years (period) the precipitation is experienced as well as to project the rainfall trend from 2003 to 2018. The Statistic Package for Social Scientists (SPSS) IBM version 20, was used to determine the Karl Pearson correlation(r) to test the relationship between the amount of precipitation and livestock production and marketing variables.

(b) Thiessen polygon method

The Thiessen's polygon method and annual station average methods were found appropriate for the available long term observed precipitation data and the distribution of the meteorological stations under study. For the larger area, the Baringo County, the Theissen polygon method (Chin, 2007) was used with six stations (see Table 4.1) to derive the areal average precipitation for the County. This method involves drawing a perpendicular bisector (see Figure 4.1, page 43) between two nearby rain gauge points before converging to a point, together with two other bisectors, to form a polygon for each representative point (Linsley et al., 2000). Equation 2 was used to estimate the Thiessen values from the Thiessen polygons. The method provides weights proportional to the size of the polygon area, pivoted by each rain gauge. In fact, this method is widely used because of its practicability, and is less time consuming with relatively highly accurate estimates (Damant et al., 1983).

In order to derive the mean areal precipitation (average amount of precipitation over), the 5-set station's data was used as per the formula;

$$\bar{P} = \frac{P_1A_1 + P_2A_2 + P_3A_3 + P_4A_4 + P_5A_5}{A_1 + A_2 + A_3 + A_4 + A_5} = \sum_{i=1}^{5} P_iA_i \qquad \text{Equation 2}$$

Where;

$\bar{P}$

Is the weighted average (See appendix 12)

P's are measurements

A's are areas of each polygon (see Table 4.1 and Figure 4.1)

Through the application of ArcGIS software, the Baringo County area was generated from Google maps and divided into several polygons, each one around a measurement point, and then a weighted average of the measurements based on the size of each one's polygon (see Figure 4.1) was taken. To plot the 6-set stations (Snake Farm, Kimose Agricultural Holding Ground, Lake Bogoria National Reserve, Perkerra Agricultural Research, Talai Agricultural Station and Chemususu Forest Station) in Baringo, the Thiessen values (weighted averages) for the 30 years of areal rainfall trends from the below areas were measured for the respective stations (see Table 4.1 and Appendix 12).

(c) Annual average method

The observed precipitation data for the Snake Farm, Kimose Agricultural Holding Ground, Lake Bogoria National Reserve and Perkerra Agricultural Research Stations were used. Annual average method was used to measure the amount of observed precipitation experienced in the study area (Mogotio and Marigat Sub-counties) which was a smaller area relative to Baringo County as a whole where Thiessen Polygon method was used. This method involved computation of annual averages for each year for a period 1974-2003 (30 years) for each of the four stations above-mentioned. Then, by use of Microsoft Excel a graph was plotted showing the rainfall trend.

3.6.2 Objective 2: Utility of indigenous and conventional weather forecasts techniques

3.6.2.1 Desk top studies

Information was collected from literature and pre-existing data on the performance of indigenous and conventional climate forecasts over the study period. This included: different understanding of ITK, why pastoralists have preferred indigenous seasonal weather predictions to conventional ones, the role ITK has played as an analogy to help new scientific seasonal weather predictions uptake, communities perception and attitude on indigenous knowledge forecasters, human engagement with the natural environment, merging of indigenous knowledge forecasters with science-based climate predictions, availability of the indigenous knowledge forecasts to farmers, and reliability of indigenous knowledge forecasts to pastoralists.

3.6.2.2 Household survey (Field work)

The open and closed semi-structured questionnaire/interview schedules were encompassed in the general questionnaire (see Appendix 1). Before the actual survey, the tool was subjected to pre-testing to gauge suitability and clarity and any appropriate changes were incorporated in the final survey tool. For the researcher to familiarise with the topography and the terrains of the study area, a reconnaissance was undertaken prior to pretesting of the data collecting tools and actual data collection. The data collected was for less or equal to five years with 2017 as the reference year. This is because it is difficult for the human being to recall events that occurred in the past. A comprehensive questionnaire was used to collect the data on perception of the pastoralists on the performance of the indigenous and conventional climate forecasts within the two sub-counties (see Figure 3.5). During the actual household survey, the enumerator after interviewing the first household skipped the fourth and interviewed the fifth household. This continued consistently along a defined route until the computed sample size was done.

The above-mentioned activities were performed to ensure quality data collection. The study population was the community in Baringo South and Mogotio sub-counties while the target population was the livestock farmers' households. The unit of analysis was the household. In order to get a good representative of the targeted population the below procedure and formula was employed;

The sample size was computed using the simple random sampling technique to draw a sample size of 454 respondents for the survey using Fishers' formula as described by Yamane (1967) and Mugenda and Mugenda (2003):

$$n = \frac{N}{1 + Ne^2}$$ Equation 3

Where **n** is the sample size, **N** the targeted population (**N**=142,570 - IEBC 2009) and ***e*** the desired level of precision or confidence level (***e*** =5%) of the sample population of 249 household etc.

The population of Baringo South Sub-County and Mogotio Sub-County, which is 142,570 (IEBC, 2009) was considered as the study population in the computation of the sample size and the level of precision was taken to be 5% level of significance. The calculations for the sample size are displayed as follows:

$$n = \frac{142570}{1 + 142570(0.05)^2} = 398.88 \approx 399$$

As recommended by Eng (2003) it is important to increase the size of the sample to cater for the non-response of the respondent. Suppose 80% was the response rate, to ensure that the gathered data was from an acceptable number of respondents it was necessary to increase the sample size from the formula by 25%. Thus, the study used a sample size of approximately 454 respondents (Kasiulevicius et al., 2006). The sample size was proportionally divided between the two sub-counties relatively to their population and area coverage. The 249 households interviewed were from Marigat (Baringo South) and 205 households from Mogotio sub-County. The actual study response rate attained was 96.4% (see Table 3.2). The actual study sample size (see) below was broken down as shown in Table 3.3

Table 3.3: Ward study sample size, interview response and rate

Sub- County	Ward	Number of Respondents Anticipated
Marigat (Baringo South)	Mochongoi	59
	Mkutani	59
	Marigat	68
	Ilchamus	63
Mogotio	Emining	72
	Mogotio	72
	Kisanana	61
Total Sample Size		**454**
Number responded		437
Response Rate		96.3%

Source: Survey 2016

The data was found to be sufficient for analysis since it was above 80% of total expectation according to Babbie (1995) who considers 70% response rate and above to be very good.

Figure 3.5 shows map of Baringo County and the specific study area showing the distribution of the households that were interviewed in the field survey. They include two sub-counties: Mogotio and Baringo south (Marigat).

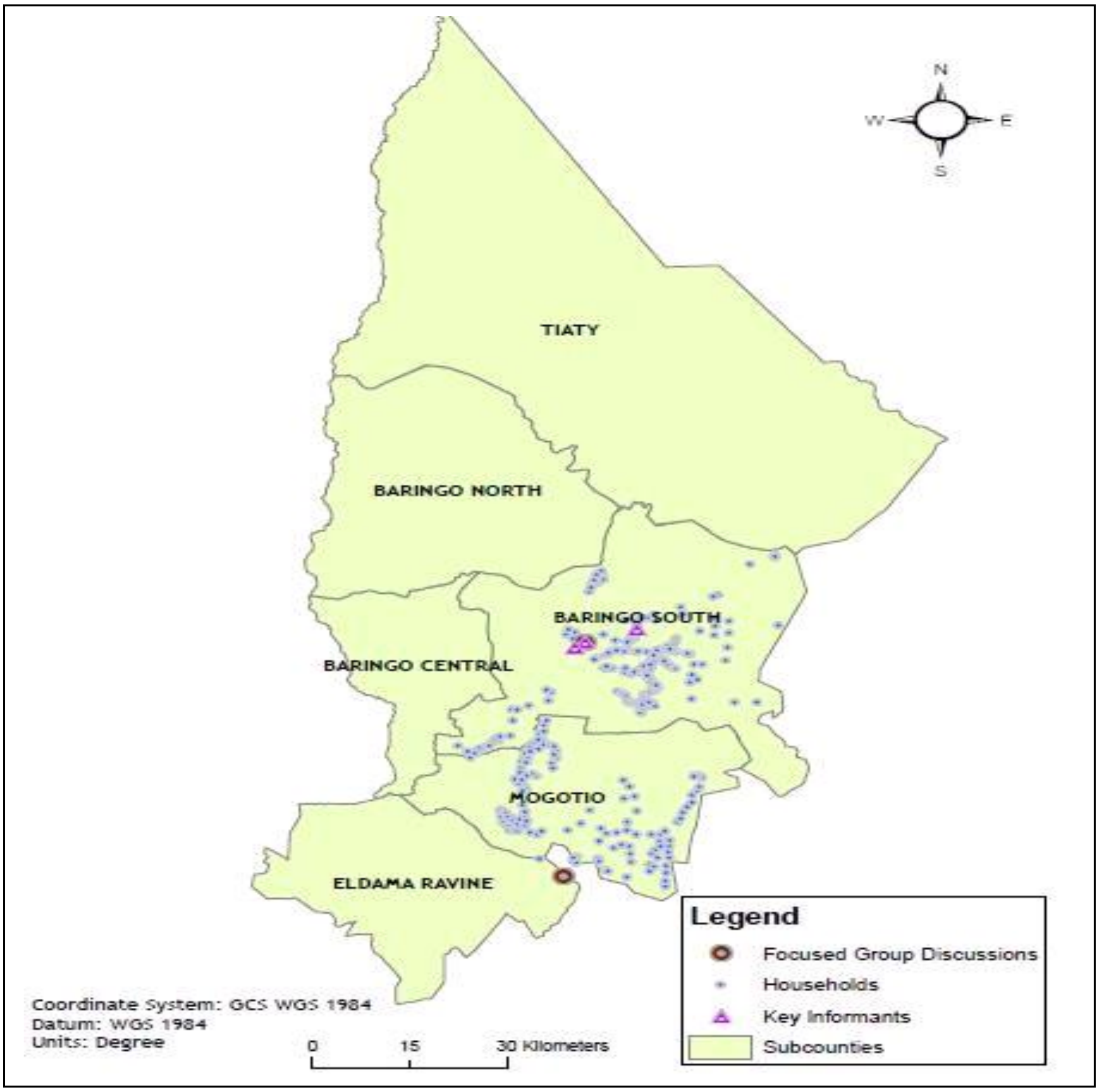


Figure 3.5: Map of Baringo County and the study area location showing the distribution of the households interviewed in the field survey

To ensure quality of the data collected, the researcher engaged seven enumerators in an intensive training (see Plate 3.1) as recommended in UN (2005). The enumerators were able to understand and internalise the content of the tool and the procedure to be followed. Further, they were trained on how to use the Global Positioning System (GPS) gadget in identifying the location of the household for interview (see Plate 3.2).

Plate 3.1: Researcher training enumerators on how to use the interview schedule in collecting survey data at KALRO-Perkerra in Marigat on 23/8/16

Plate 3.2: Training enumerators on how to use GPS equipment at KALRO-Perkerra on 23/8/16

Plate 3.3: FGD in progress at Mogotio Livestock Improvement Centre on 30/8/2016

3.6.2.3 Focus group discussion

The Participatory Rural Appraisal (PRA) methods namely key informant interviews and Focus Group Discussions (FGDs) were also used in data collection. On 30th August 2016 an FGD was conducted at Livestock Improvement Centre in Mogotio Sub-county. The group comprised ten participants where two came from each of the following categories: pastoralists, agro-pastoralists, traditional rain makers, livestock traders and livestock extension officers (see Plate 3.3). In the recruitment of the FGD participants, the age and gender were considered. This corroborates Saunders et al. (2007), where a typical focus group discussion involves four to twelve participants depending on interviewer skill and subject matter. The same type of composition of the participants applied to the other FGD that took place on 25th August 2016 at the Ministry of Agriculture, Livestock, Fisheries and Irrigation offices in Baringo South Sub-county. Thus, a total of two focus group discussions were conducted; one FGD per Sub-County. A Focus Group Discussion guide was used to moderate the discussion (see Appendix 3). The discussions were tape recorded and notes were taken to ensure that no issue was missed in the exercise.

3.6.2.4 Key informants' interview

Key Informant (KI) interview schedules were used in collecting information from ten Key Informants (see Appendix 2). They were purposely sampled from the Baringo County. They included interviewees from Ministry of Livestock and Fisheries, Ministry of Agriculture, Kenya Meteorological Department, Kerio Valley Authority, National Drought Management Authority, Pastoralist weather forecaster ("rain maker"), World Vision, Livestock trader, Agricultural Sector Development Support Programme (ASDSP) and slaughter house managers. The notes' taking and tape recording were undertaken to enhance the data collection.

3.6.2.5 Data analysis

As an aspect of quality data control, the dataset obtained from the household interviews was computed to establish the interview response and rate (see Table 3.3). The household survey dataset was cleaned by visually identifying incomplete, incorrect, inaccurate, irrelevant, parts of the data and then replacing, modifying, or deleting the dirty data in the IBM SPSS statistics data editor sheet. Then the data was analysed for frequencies and descriptive and bivariate inferential statistics using a confidence level of 95%.

For the qualitative data from FDGs and some from KI, content analysis (Cole, 1988; Cavanagh 1997) was employed. It involved the researcher transcribing the above-mentioned data into interview transcripts and analysed by coding and organising it into themes and concepts (Mugenda and Mugenda, 1999). The qualitative findings assisted the researcher to interpret and explain the complex reality of the given situation and any implication of the quantitative data.

3.6.3 Objective 3: Impacts of integrated weather forecasts techniques on livestock production and marketing

3.6.3.1 Desk top studies

The different kind of information on indigenous and scientific seasonal weather predictions and how it has impacted on the livestock production and marketing was assessed. The information on seasonal weather predictions methods as a climate risk management tool was also sourced from online source and university libraries. Further information studied included: possibility of combining the indigenous and scientific methods of seasonal weather predictions, importance of seasonal weather predictions, what influences pastoralists movements, the potential for using seasonal weather prediction to address climate-related risk, general understanding of climate risk management and prior-knowledge of climate condition in development of seasonal climate risk management strategy.

3.6.3.2 Field studies

The non-probability sampling design was used in drawing ten key informants from government officials (livestock extension officers, ASDSP, Livestock co-operative marketing officers, NGOs strikes World Vision and Kerio Valley Authority). The field work for objective two, three and part of four started on 24th August 2016 and was completed on 9th September 2016. It entailed; interviewing 437 households, interviewing ten Key Informants and conducting two Focus Group Discussions and a stakeholders' engagement forum. In objective three the same methodology as in objective two was applied. The data on impact of indigenous and conventional seasonal weather forecasts on livestock production and marketing in a changing climate was collected by use of the part of the questionnaire.

3.6.3.3 Data analysis

The same procedure was followed as in objective two. The dataset comprised the household survey results, KI interviews, and FGDs. SPSS was used to analyse the household survey data where descriptive (frequencies and percentages) statistics were done. For the KI and FGDs themes were developed, and narratives were compiled. Further the bivariate analysis was undertaken using paired t-test to compare means on the impact of indigenous and conventional seasonal weather forecasts on performance of livestock production and marketing in a changing climate.

3.6.4 Objective 4: Recommended interventions

The fourth objective involved coming up with recommendations of interventions from the findings of the above objectives to enhance efficiency and effectiveness in livestock production and marketing in the context of climate change and variability.

3.6.4.1 Desk top studies

The relevant literature on livestock production and marketing in ASAL in the context of climate change was reviewed. The information on general livestock marketing among pastoral communities, analysis of marketing data, stakeholders in livestock marketing in Mogotio and Baringo south sub-counties and similar studies conducted in the past was reviewed. Also, the respondents' views on what can enhance efficiency and effectiveness in livestock production and marketing in the context of climate variability and change were analysed, interpreted and recommendations drawn.

3.6.4.2 Data analysis

Along with other above-mentioned analysis the researcher further undertook stakeholder analyses. It entailed compiling the data collected from the identified key stakeholders through a check list filled in the stakeholder table; this step of the process involves preparing a "stakeholder table" or arranging the answers of the interview and other the secondary information collected into a concise and standardized format. The purpose behind this was to make systematic comparisons, highlight the most significant information, and to ensure stakeholder identity anonymity if required. This allowed the researcher to develop clear comparisons among the different stakeholders and the information was used to come up with the recommended interventions.

3.6.5 Data synthesis

To examine the impacts of seasonal climate variability and weather forecasts on livestock production and marketing in the face of climate change and recommend interventions for

Baringo County, Kenya, the researcher undertook the following methods and procedures. Rainfall data for six stations and air temperature data for four stations located in Baringo County were used in this study. The Theissen polygon and station average methods were applied in generating rainfall trends through linear regression analysis. To examine the impact of rainfall and air temperature on livestock production and marketing, scatter diagrams and correlation coefficient were applied. Further, to determine the impact of the weather forecast, a household survey was undertaken that involved various data collection techniques namely, face to face interview, Focused Groups Discussions, Key Informant interviews, photography and personal observations to ensure triangulation (Blanche et al., 2006). Stakeholders' consultative forum was applied as a transdisciplinary approach to generate recommendation/ intervention. Therefore, to address the above-mentioned main study objective, the triangulation of the findings was embraced.

CHAPTER FOUR: IMPACTS OF SEASONAL CLIMATE VARIABILITY ON LIVESTOCK PRODUCTION AND MARKETING IN BARINGO COUNTY

4.1 Introduction

This chapter describes the climate variability and its impacts on livestock production and marketing in Baringo County. It addresses objective one of the study. It starts with presentation and discussion of the precipitation variability trends from 1974-2003 in two Sub-counties (Baringo South, and Mogotio) and the larger Baringo County by use of the station average and Theissen polygon methods respectively. Also, the observed air temperature variability trends from 1980 to 2009 for Baringo County are presented and discussed. Further, the livestock production and marketing data is highlighted. This is followed by the description of the mean areal precipitation (climate variability) impact on the two above-mentioned aspects. It is sequentially presented as follows; impact on population of cattle, goats and sheep, number of hectares of improved pasture, natural and fodders development in Baringo County (1998-2003) cattle goat and sheep prices, and the quantity of livestock sold for slaughter.

4.2 Results

4.2.1 The Thiessen polygons

Table 4.1 shows the six weather stations whose long term observed precipitation data were used in this study. This data was used in the construction of the Theissen polygons (Figure 4.1) and for computing the Theissen values/weighted averages.

Table 4.1: Area in Km^2 covered by respective weather stations in Baringo County

S/No.	Station Name	Area in Kilometers squared
1.	Snake Farm - Lake Baringo	306.724
2.	Chemususu Forest Station	348.842
3.	Kimose Agricultural Holding Ground	889.485
4.	Lake Bogoria National Reserve	880.314
5	Perkerra Agricultural Research	680.039
6	Talai Agricultural Station	800.355

The long-term observed precipitation data for Kabimoi Agricultural Holding could not meet the threshold for the analysis since it lacked data for five years unlike the other six weather stations. It was therefore, omitted in any further process and analysis. In the Figure 4.1 below, Chemususu, Kimose and Talai are located in the highlands. Among all the meteorological stations shown in the Figure 4.1 below Kimose covers the largest area (889.485km^2) and Snake Farm the lowest (306.724km^2) .

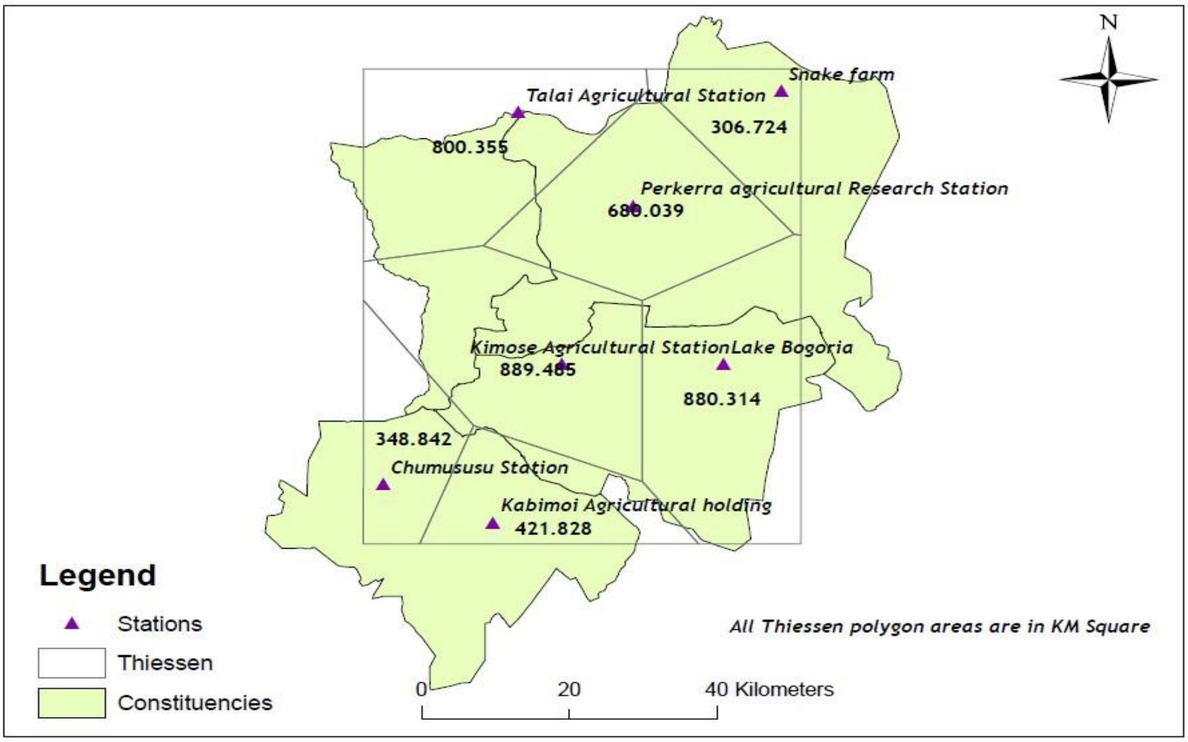


Figure 4.1: Map of Baringo County showing generated polygons on the distribution of the weather station in the study area,Baringo County.
Source: Google map and author 2016

4.2.1 Mean areal precipitation trend by use of station average method

Figure 4.2 shows the estimated mean areal precipitation trend for four weather stations namely; Snake Farm, Kimose, Lake Bogoria and Perkerra for the period 1974-2003 and covering 2757 km^2 in Mogotio and Baringo South sub-counties. It further shows the highest and lowest estimated mean areal precipitation of 1081.10 mm in 1977 and 277.90 mm in 1984, respectively. The range between the highest and the lowest is 803.20 mm, implying that there has been a big variation in the amount of precipitation in the years under review. The mean value is 706.07 mm ± 178.13 mm. The Standard Deviation (SD) indicates the high year to year variability. From the trend equation, the predicted mean areal precipitation for the year 2018 (15 years from 2003) was 707.28 mm. The linear regression line shows a negative slope of 2.41 mm per year, demonstrating a decreasing trend in mean areal precipitation. The regression equation, R^2=0.01, and the ($P>0.05$) shows that it is not significant.

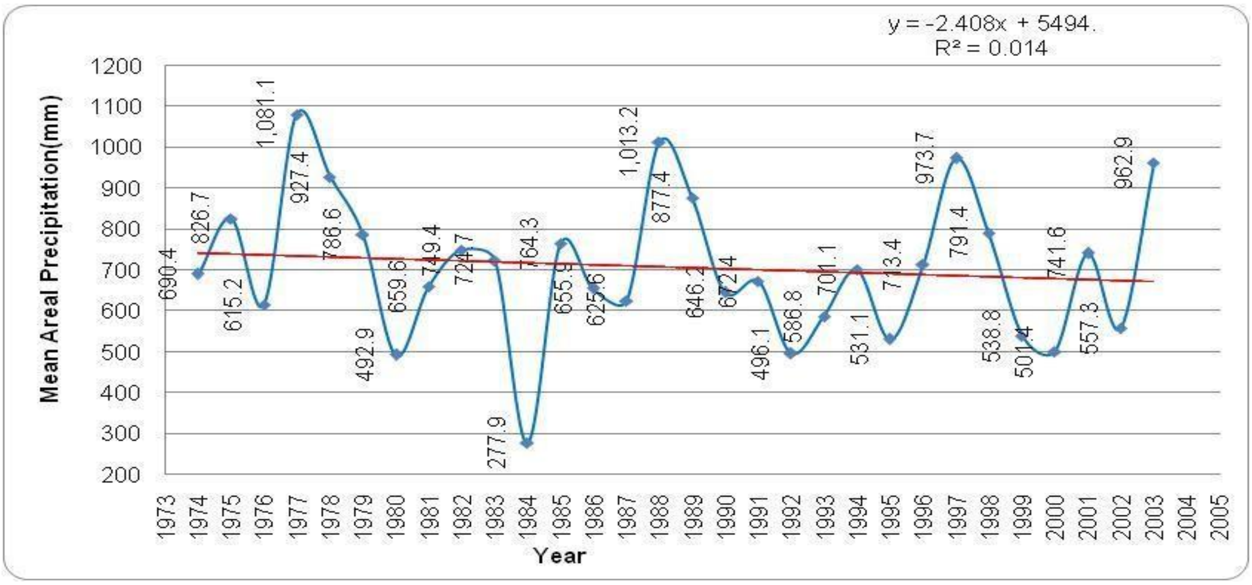


Figure 4.2: Estimated mean areal precipitation trend by use of average method for four weather stations within the study area (Snake Farm, Kimose Agricultural Holding Ground, Lake Bogoria National Reserve and Perkerra Agricultural Research Station)

Source: KMD Observed precipitation data (2016)

4.2.2 Mean areal precipitation trend by use of Theissen polygon method

Figure 4.3 shows the estimated mean areal precipitation trend for the six weather stations namely; Snake Farm, Kimose, Lake Bogoria, Chemususu, Talai and Perkerra for the period 1974-2003 and coverage of 3905.76 km^2 in the larger Baringo County. It further shows that the highest and the lowest estimated mean areal precipitation was 1298.65 mm in 1988 and 359.59 mm in 1984, respectively. The range between the highest and the lowest was 939.05 mm, implying that there has been a big variation in the amount of precipitation over the years under review. The mean value is 868.12 mm ± 207.56 mm. The high Standard Deviation reflects high variability from year to year.

From the trend equation, the predicted mean areal precipitation for the year 2018 (15 years from 2003) was expected to be 870.47 mm. The linear regression line shows a negative slope of 4.72mm per year, indicating a general decreasing trend in mean areal precipitation, which suggests that the rainfall was decreasing in the study area. However, for the regression line equation, R^2= 0.04, and the ($P>0.05$) shows that it is not significant.

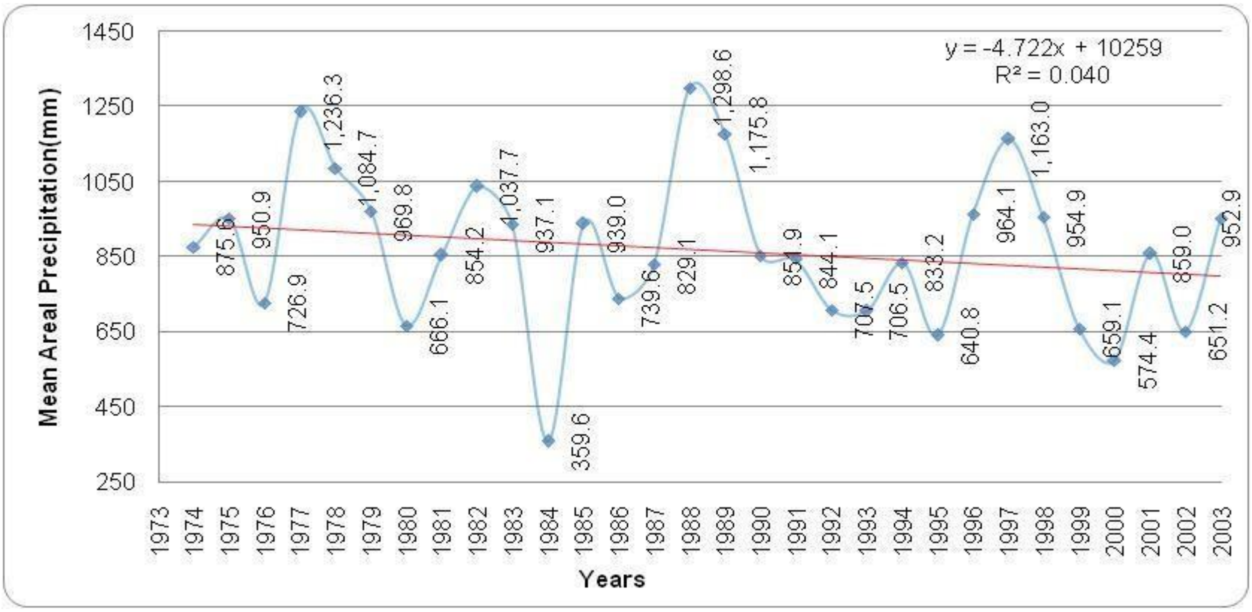


Figure 4.3: Estimated mean areal precipitation trend by use of Theissen polygon method for six weather stations, 1974-2003

Source: KMD Observed precipitation data (2016)

4.2.3 Individual stations annual precipitation trends

Table 4.2 below shows that the area covered by Lake Bogoria weather station experienced the biggest variation in rainfall with a coefficient of variability (CV) of 30%, followed by Snake Farm (29%) and lastly Perkerra Agricultural Research Station. All this coverage is in the lowlands. The lowest CV of 19.4%was recorded at Chemususu, located in the highlands. The highest mean annual rainfall of 1139 mm ± 221.37 mm was recorded at Chemususu and lowest of 612.32 mm ± 179.27 mm at Perkerra. The highest maximum annual rainfall of 1716 mm was recorded at the area covered by Chemususu while the lowest was 1087 mm at Perkerra. The area that experienced the highest minimum annual rainfall of 656 mm was Chemususu and the lowest was 247 mm at the Lake Bogoria station. Based on the rainfall trend analysis for 1974-2003, rainfall at Perkerra, Chemususu and Snake Farm weather stations was declining at a rate of 4.00 mm to 9.18 mm per year.

Table 4.2: Summary of mean annual, max. and min. annual rainfall, rainfall decrease per year and coefficient of variability for five weather stations 1974-2003

Weather stations	**Chemususu**	**Kimose**	**Perkerra**	**Snake Farm**	**Lake Bogoria**
Aspect of measure					
Mean annual rainfall(mm)	1139±221.37	857.19±236.8	612.32±179.27	668.31±194.57	658.36±198.36
Max. annual rainfall(mm)	1716	1341	1087	1115	1010
Min. annual rainfall(mm)	656	365	264.8	262	247
Rainfall decrease per year (mm)	5.39	2.4	9.18	4.07	0.85
*CV (%)	19.4	28	29	29	30

*Coefficient of variability

The annual rainfall trends for the individual five weather stations namely; Chemususu, Perkerra, Kimose, Snake Farm and Lake Bogoria were plotted in one graph (Figure 4.4). The linear regression shows a negative slope of 5.40 mm per year indicating that the general amount of rainfall received in the station is reducing every year. The trend yielded an R^2 = 0.05, which was not statistically significant (P>0.05). In Kimose Weather Station, the linear regression line shows a decrease of 2.41 mm per year. The trend yielded an R^2 = 0.01, which was not statistically significant (P>0.05). For Snake Farm around Lake Baringo the trend shows an evidence of variation in the annual rainfall. The linear regression line shows a negative slope of 4.07 mm per year, indicating a decreasing trend in mean areal precipitation. The trend yielded an R^2 = 0.03, which was not statistically significant (P>0.05).

The trend of annual rainfall recorded in Lake Bogoria National Reserve shows the slope of the regression line is negative 0.85 mm per year. The trend yielded an R^2 = 0.001, which was not statistically significant (P>0.05). In Perkerra Agricultural Research Station is noted that the trend yielded a linear regression line showing a negative slope of 9.178 mm per year depicting that the annual rainfall observed is continually decreasing. The trend yielded an R^2 = 0.20, which was not statistically significant (P>0.05).

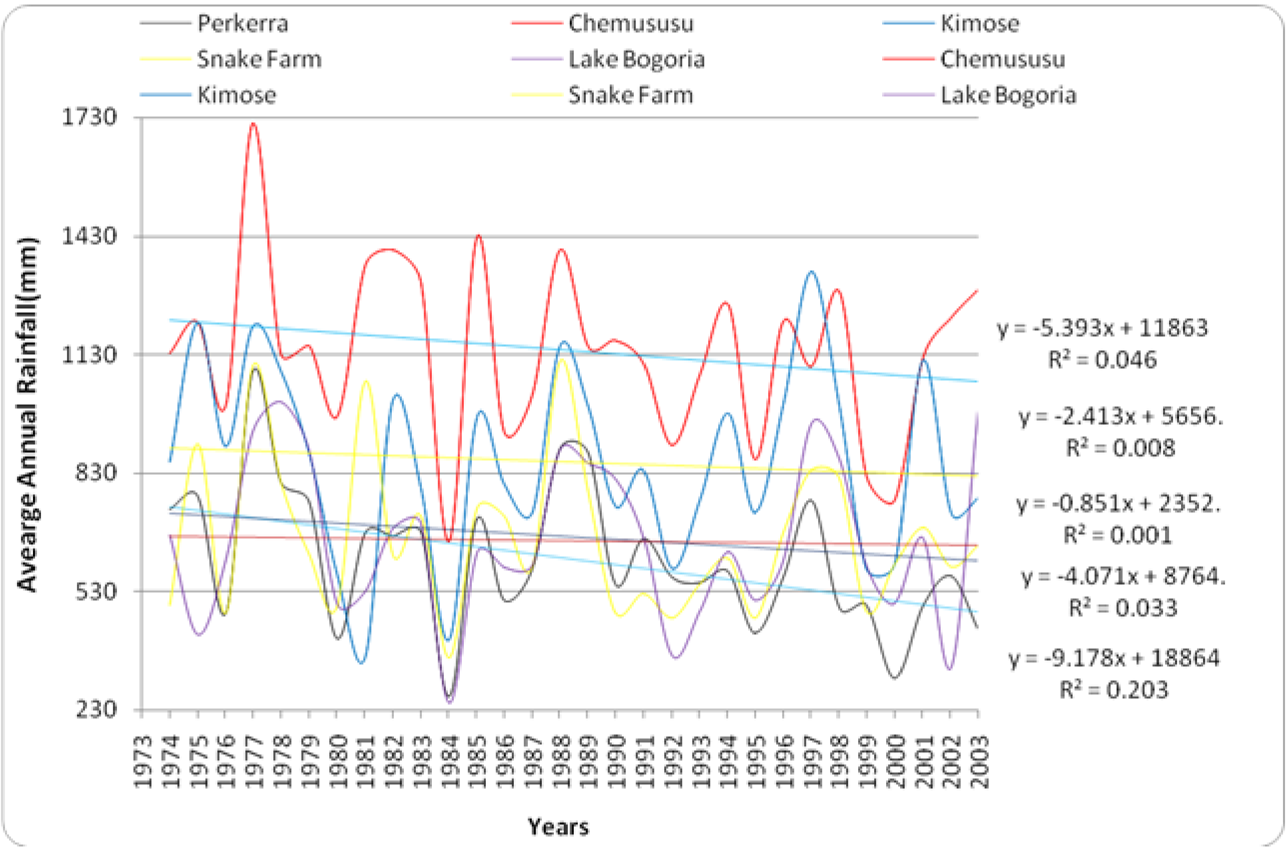


Figure 4.4 Combined individual stations annual rainfall trends from 1974-2003
Source: KMD observed precipitation data (2016)

4.2.4 30 years monthly and seasonal average precipitation

The researcher further analysed: the monthly average precipitation trends, monthly average and precipitation seasons. The following sub-sections present the results.

Figure 4.5 above shows the monthly average precipitation trends for Perkerra Agricultural Research Station, Snake Farm and Lake Bogoria National Park Reserve (three stations) in the study area for 30 years. Among the six weather stations considered for this study, the above-mentioned three stations are located within the study area (Mogotio and Baringo South Sub-counties).

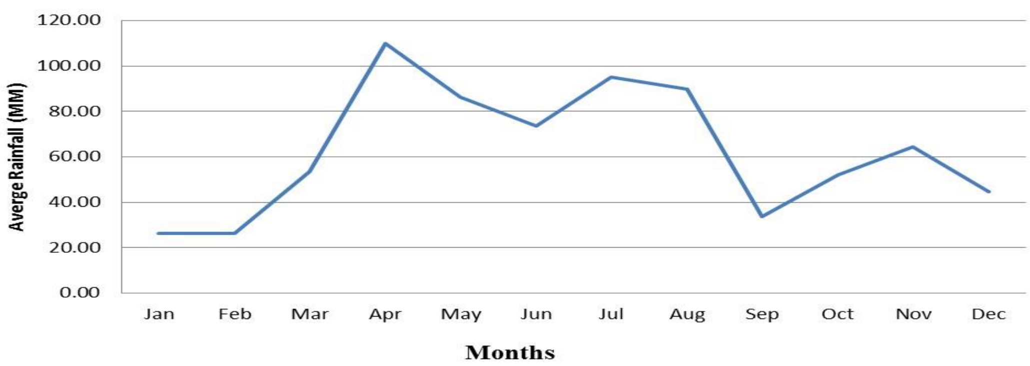


Figure 4.5: Monthly average precipitation trends in the study area (3 stations) for 30 years

The highest and lowest amount of monthly average precipitation recorded was 110 mm in April and 25 mm in January, respectively. The plotted trend shows variation.

Figure 4.6 shows the highest average amount of rainfall received (99.01mm) was in the long rain season for the period under review.

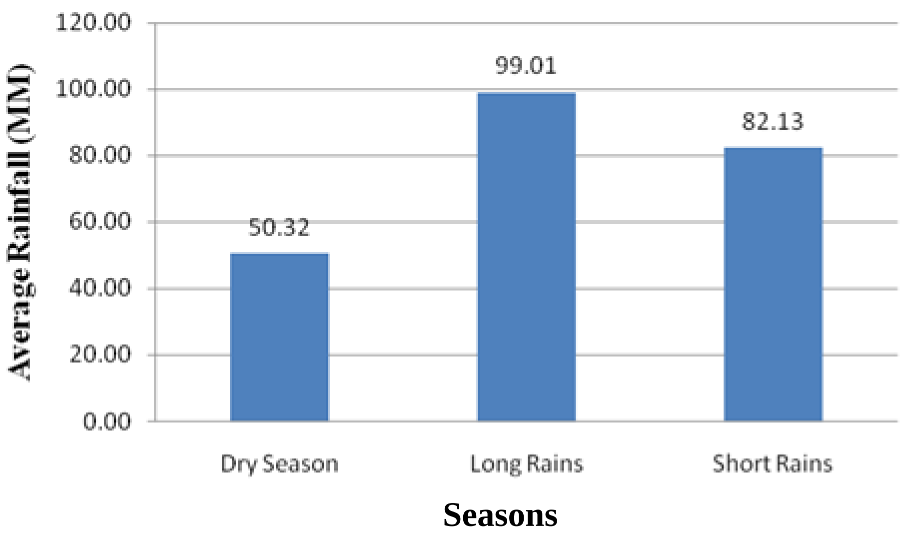


Figure 4.6: Monthly average rain seasons in the study area (3 stations) for 30 years

Figure 4.6 demonstrate that the highest monthly average rain season of 99.01mm was experienced in a long rain season within the period under review in the study area. Mogotio and Baringo south sub-counties in Baringo County experience two rainfall seasons and one dry season annually. They are; long rainfall season (March, April and May), short rainfall season (October November and December) and dry season (January-March).

4.2.5 Relationship between rainfall and livestock production and marketing

The sub-section below is the presentation of the results of the annual mean areal precipitation on specific selected attributes/variables of livestock production and marketing in the study area under review. Livestock production variables included the population of livestock species (cattle, goats and sheep) and number of hectares of Napier, improved pasture, natural pasture and fodder trees developed within the period under review.

Table 4.3: Number of cattle, sheep, goat and poultry owned by a household

Parameter	Species of livestock			
	Cattle	Goats	Sheep	Poultry
N	417	408	369	280
Mean	21	27	20	23
Median	18	24	20	20
Mode	15	30	20	20
Std. Deviation	13.08	16.22	12.28	13.16
Minimum	1	1	1	1
Maximum	70	150	90	77

Source: Household survey (2016)

The Table 4.3 above shows 417 cattle, 408 goats, 369 sheep and 280 poultry were owned by the interviewed households at the time of the survey. Each household owned an average of 21 cattle, 27 goats, 20 sheep and 23 poultry, respectively. The maximum one household could own were; 70 cattle, 150 goats, 90 sheep and 77 poultry. The findings indicate that there were more goats in each household than all the other species of livestock. This also applied to the maximum number of livestock species each household could own, goats were the highest as shown in Table 4.2. This finding was supported by KI who said, "*We prefer rearing goats since they are hardy to the coarse environment in Marigat and Mogotio, in that they can browse from the shrubs, require little water and perform well in dry seasons than cattle and sheep. Also they have a higher demand in the auction yards"*.

Figure 4.7 below shows scatter diagrams and correlation coefficient (covariance) between the mean areal precipitation and population of cattle, goats and sheep for the period 1999-2003 under review. The relationship of the above two variables establishes the impact of rainfall on the population of the livestock species under review. The analysis shows correlation coefficient of r=-0.87, r= 0.55, r= 0.32 for cattle, goats and sheep, respectively. The above-mentioned findings show that there is a moderate negative relationship between rainfall and the population of cattle. For the case of goats and sheep the relationships are positive although for the sheep in particular is a very strong one and the trend yielded an R^2 = 0.517, which was statistically significant.

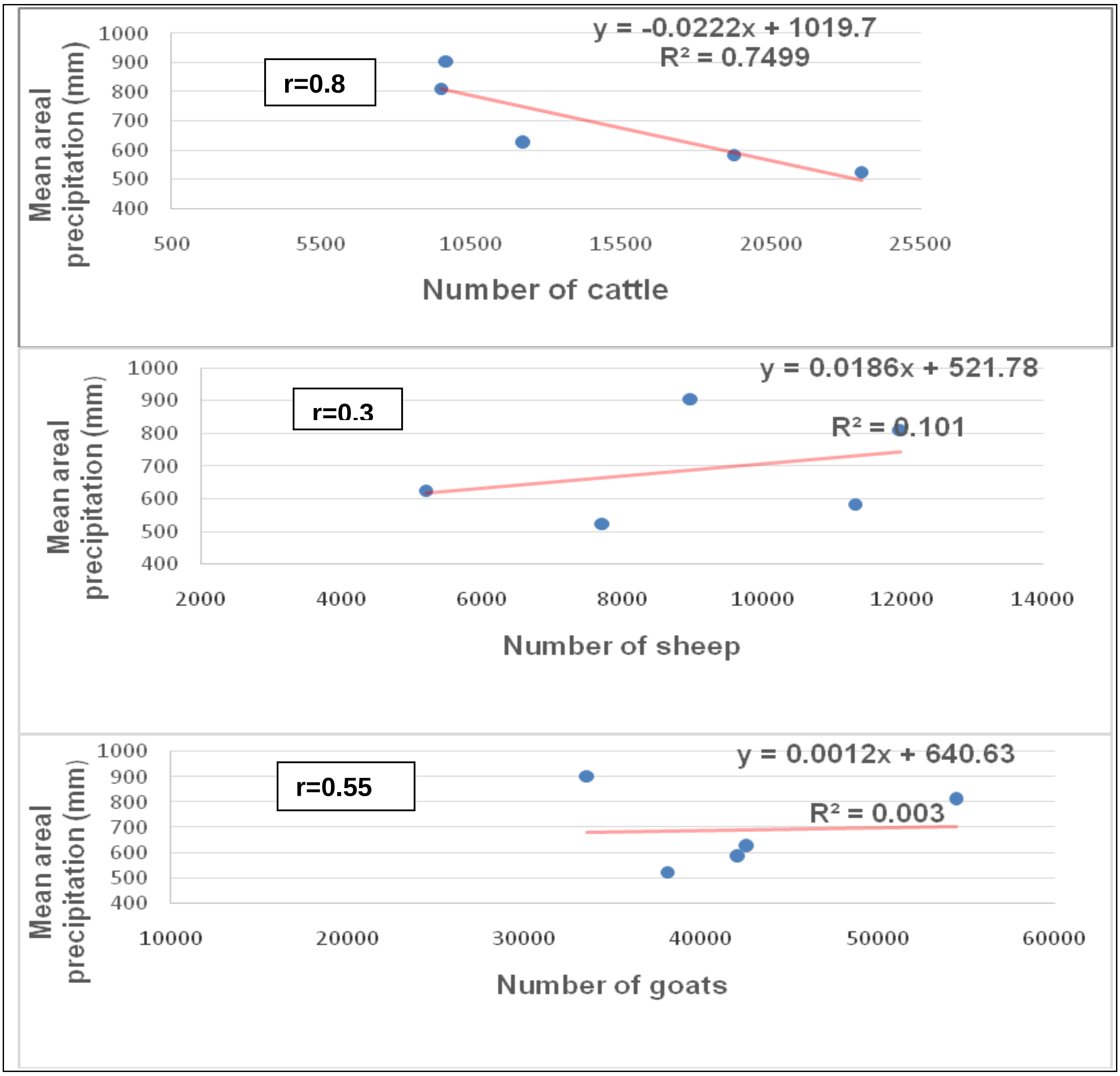


Figure 4.7: Scatter diagrams for the livestock population (cattle, goat and sheep) in Marigat and Mogotio Sub-Counties, 1999-2003 in Baringo County

Source: GOK 2009 Ministry of Livestock Development. Livestock Production Annual Report, Rift Valley, Kenya.

Figure 4.8 below shows the relationship between the mean areal precipitation and the developed hectares of Napier, improved pasture, natural pasture, and fodder trees for livestock feed for the period 1999-2003.

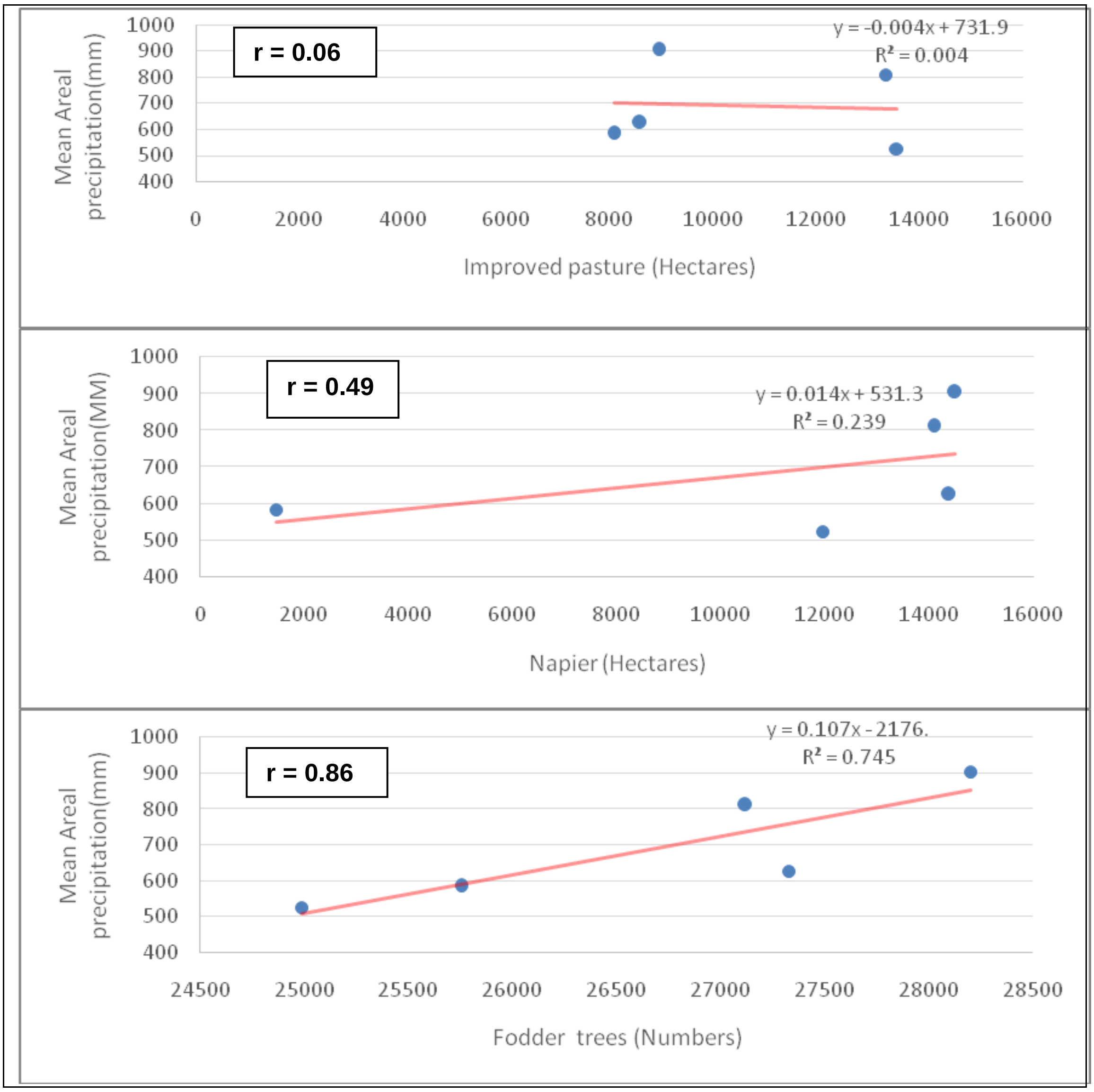


Figure 4.8: Scatter diagrams for the hectares of Napier, improved pasture and natural pasture and fodder trees developed from 1998-2003 in Baringo County

Source: (GOK, 2009) Ministry of Livestock Development. Livestock Production Annual Report, Rift Valley, Kenya

The analysis shows correlation coefficient of r = 0.49, r = -0.06, r = 0.56, r = 0.86 for Napier, improved pasture, natural pasture and fodder trees, respectively. This implies that there is a very strong relationship between the number of fodder trees established and the amount rainfall received. Therefore, as the amount rainfall increased along the study period, the number of fodder trees established also increased. However, the case of improved pasture was very different since there was no relationship at all but moderate for Napier.

4.2.6 Mean areal precipitation response to annual average livestock prices, 1999-2003

Table 4.4 below shows unit average prices for cattle, goat and sheep for the period between 1999 and 2004**.**

Table 4.4: Annual average prices of livestock in Baringo County (1999-2003)

	Livestock Species		
Parameter	**Cattle**	**Goats**	**Sheep**
N (years)	5	5	5
Minimum	8250	1500	850
Maximum	14550	2850	1550
Mean	11870	2100	1280
Std. Deviation	331	486	257

Across the livestock species in the study, cattle had the highest mean price of Ksh.14,500 and sheep had the lowest mean price of Ksh.850. For the case of sheep and goats, the latter was more expensive than the former. This implies that there was a big demand for the goats unlike the sheep in the market. Also goats had the highest SD of 486 relative to the mean. This implies that, there was a wide variation in the price than the other species of livestock in the study.

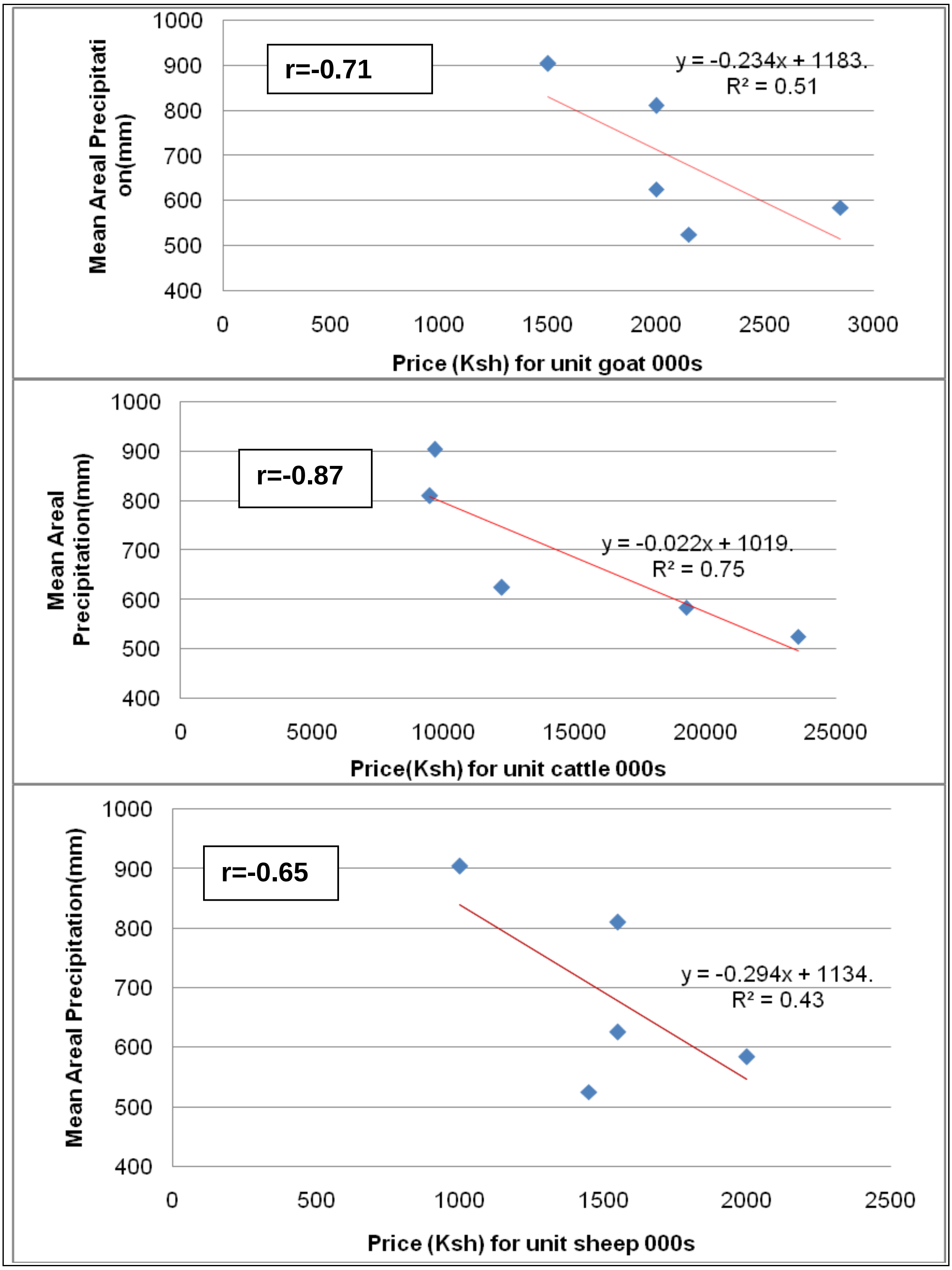


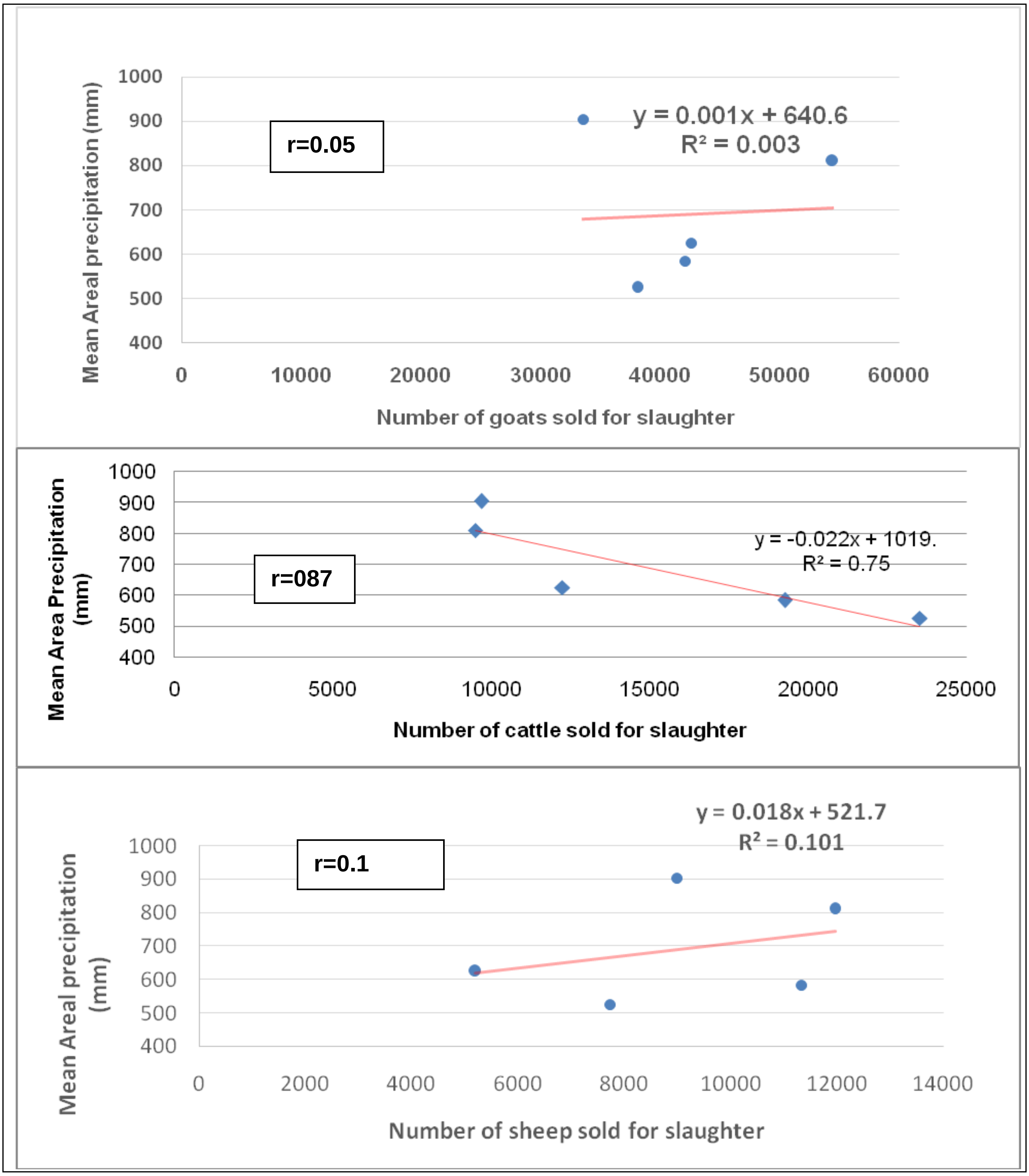
Figure 4.9: Scatter diagrams for the prices of individual unit livestock species sold for slaughter from 1999-2003 in Baringo County

Source: GOK 2009 Ministry of Livestock Development. Livestock production annual Report, Rift Valley, Kenya

Figure 4.9 above shows scatter diagrams and correlation coefficient (covariance) between the mean areal precipitation and annual average price of cattle, goats and sheep for the period 1999-2003 under review. The analysis shows correlation coefficient of r = -0.87, r = -0.71, r = -0.65 for cattle, goats and sheep, respectively. This implies that there was a strong negative relationship between the unit price of cattle, sheep and goat within the period of five years 1999-2003.

4.2.7 Mean areal precipitation response to quantity of livestock sold for slaughter from 1999-2003

Figure 4.10 below is a scatter plot line diagram showing the impact of the seasonal climate variability on the livestock. Further the scatter plots show how much of the livestock marketing variables are affected by seasonal climate variability.



Source: GOK 2009 Ministry of livestock development. Livestock production annual Report Rift Valley, Kenya

Figure 4.10 Scatter diagrams for the quantity of cattle, goat and sheep sold for slaughter from 1999-2003 in Baringo County

Figure 4.10 above shows scatter diagrams and correlation coefficient (covariance) between the quantity of cattle, goat and sheep sold for slaughter and the mean areal precipitation, for the period 1999-2003 under review in Baringo County. The analysis showed correlation coefficient of r = -0.87**,** r = -0.05, r = 0.1 for cattle, goats and sheep respectively.

4.2.8 Air temperature trends for Baringo County

This sub-section examines annual average maximum temperature trends of four weather stations. Table 4.5 below shows the meteorological stations and their locations in Baringo County that provided air temperature data for this study.

Table 4.5: Meteorological stations and their locations in Baringo County

No.	Station Name	Latitude	Longitude	Elevation
1	Snake Farm-Lake Baringo	0.63	36.15	975
2	Talai Agricultural Station	0.6	35.83	2134
3	Lake Bogoria	0.25	36.08	1067
4	Perkerra Agricultural Research Station	0.47	35.97	1067

The gridded minimum and maximum temperature data is from the University of East Anglia Climate Research Unit (CRU) Version TS3.22 at 0.5° spatial and monthly temporal resolution, spanning 1980 to 2009. . The CRU data is created by interpolation of station datasets at 0.5° by 0.5° spatial resolution. The CRU version TS3.22 data is described by Harris et al. (2014).

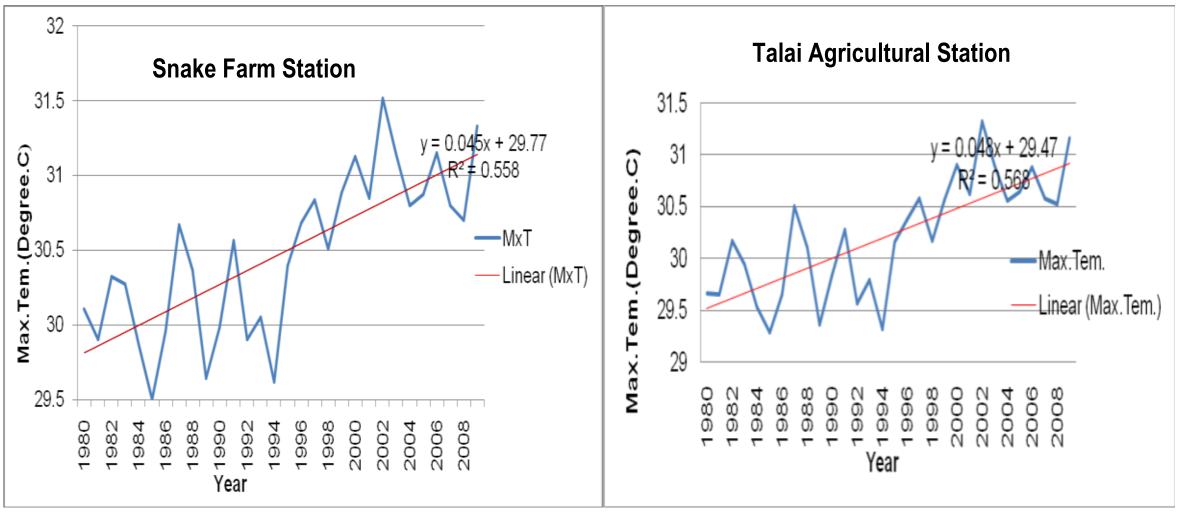


Figure 4.11: Annual average maximum temperatures trends of the Snake Farm and Talai Agricultural Station in Baringo County.

Source: Climate Research Unit at the University of East Anglia (2016)

A trend was generated for the annual average maximum air temperature experienced in Snake Farm around Lake Baringo (Figure 4.11). Based on the trend, the highest annual average maximum temperature recorded was 31.5°C in 2002 where the lowest 29.5°C was recorded in 1985. From the recorded annual average maximum temperature 31.5 °C in Snake Farm Station, the standard deviation was 0.538 which is very low, showing that there have not been great variations of the annual average maximum temperature over the 30 years study period.

From the trend equation, the predicted annual average maximum temperature for the year 2018 is expected to be 31.35°C. For the regression line equation, the R^2 = 0.558, indicating that 55.8% of the annual average maximum temperature could be explained by the time series. The nature of the relationship as indicated by p-value= <0.05 is statistically significant.

From Figure 4.11, it was manifested that there is climate change and variability as shown by the annual average maximum temperature variations. The annual average maximum temperature recorded in the station was 31.52°C in 2002 while the minimum was 29.5°C that was recorded in 1985. The standard deviation computed from the recorded annual average maximum temperature in Talai Agricultural Weather Station was 22.37 which is very high relative to the mean. This indicates that the annual average temperature experienced for the 30 years (1980-2009) was not consistent.

Figure 4.12 below shows annual average maximum temperatures trends of two weather stations; Lake Bogoria National Reserve and Perkerra Agricultural Research Station in Baringo County.

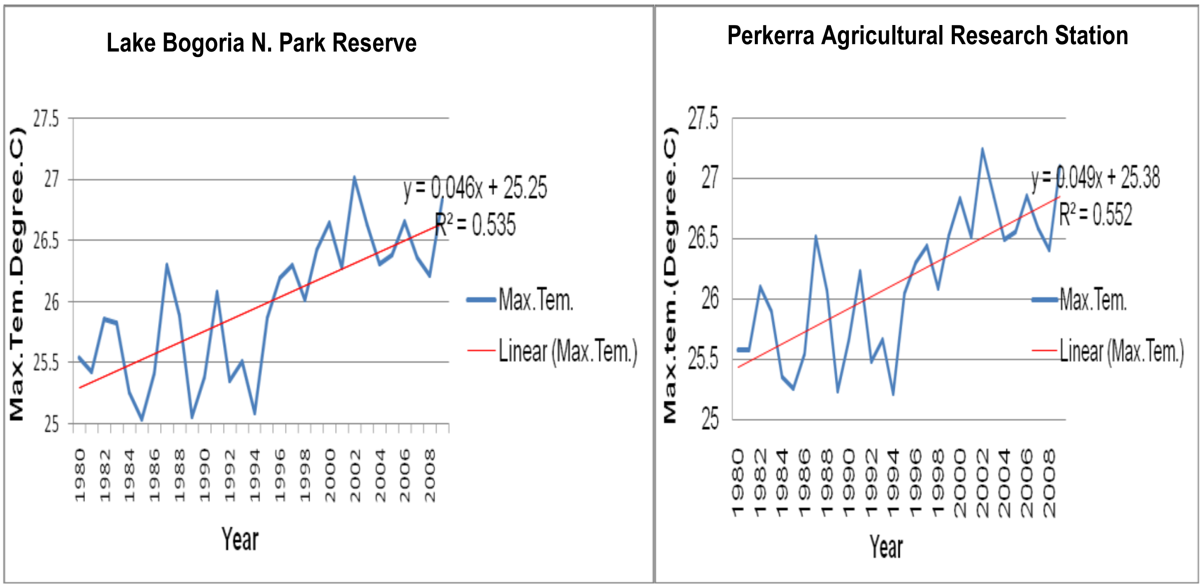


Figure 4.12: Annual average maximum temperatures of Lake Bogoria National Reserve and Perkerra Agricultural Research Station, in Baringo County.

Source: Climatic Research Unit at the University of East Anglia (2016)

In Figure 4.12 the same behaviour of the annual average maximum temperatures trend is demonstrated as in Figure 4.11. There is oscillation in the trend which demonstrates variation of air temperature across the period under review. The increase in air temperature is also seen in the trend across the period under review as in Figure 4.11.

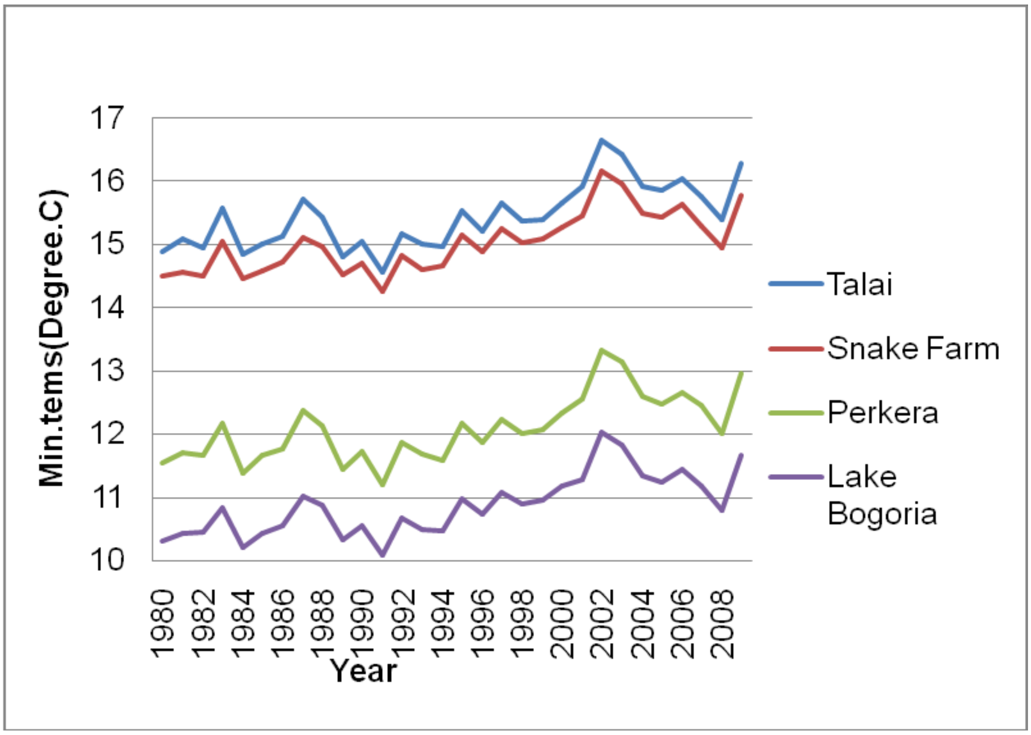


Figure 4.13: The annual minimum temperatures for the four station in Baringo County for the period 1980-2008

Source: Climatic Research Unit at the University of East Anglia (2016)

Figure 4.13 indicates that each station had its own trend of the annual minimum temperatures that is different from the others, although all the stations demonstrated general increase of temperature. The trends in Talai and Snake Farm are more less the same where minimum temperatures in 1980-82 were ranging from 14.5°C and 15°C, respectively. The trends in Perrkera and Lake Bogoria are more less the same where minimum temperatures in 1980-82 were ranging from 10.5°C to 11.5°C, respectively.

Figure 4.14 below shows the annual maximum and minimum temperatures trends for the four Station in Baringo County for a period of 30 years.

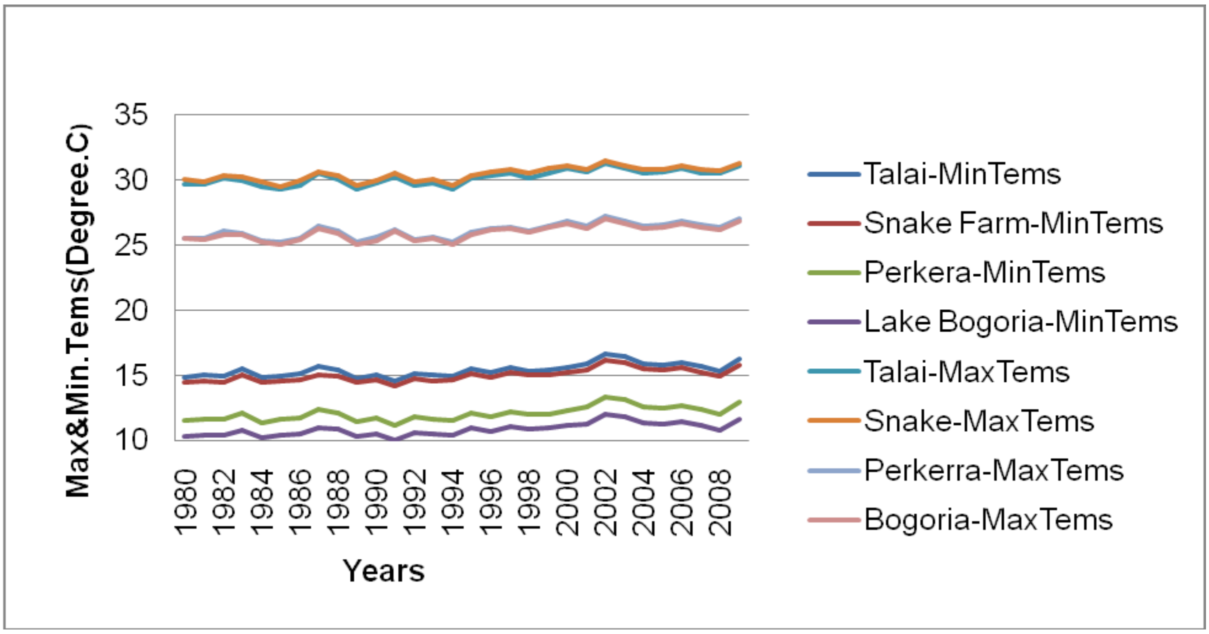
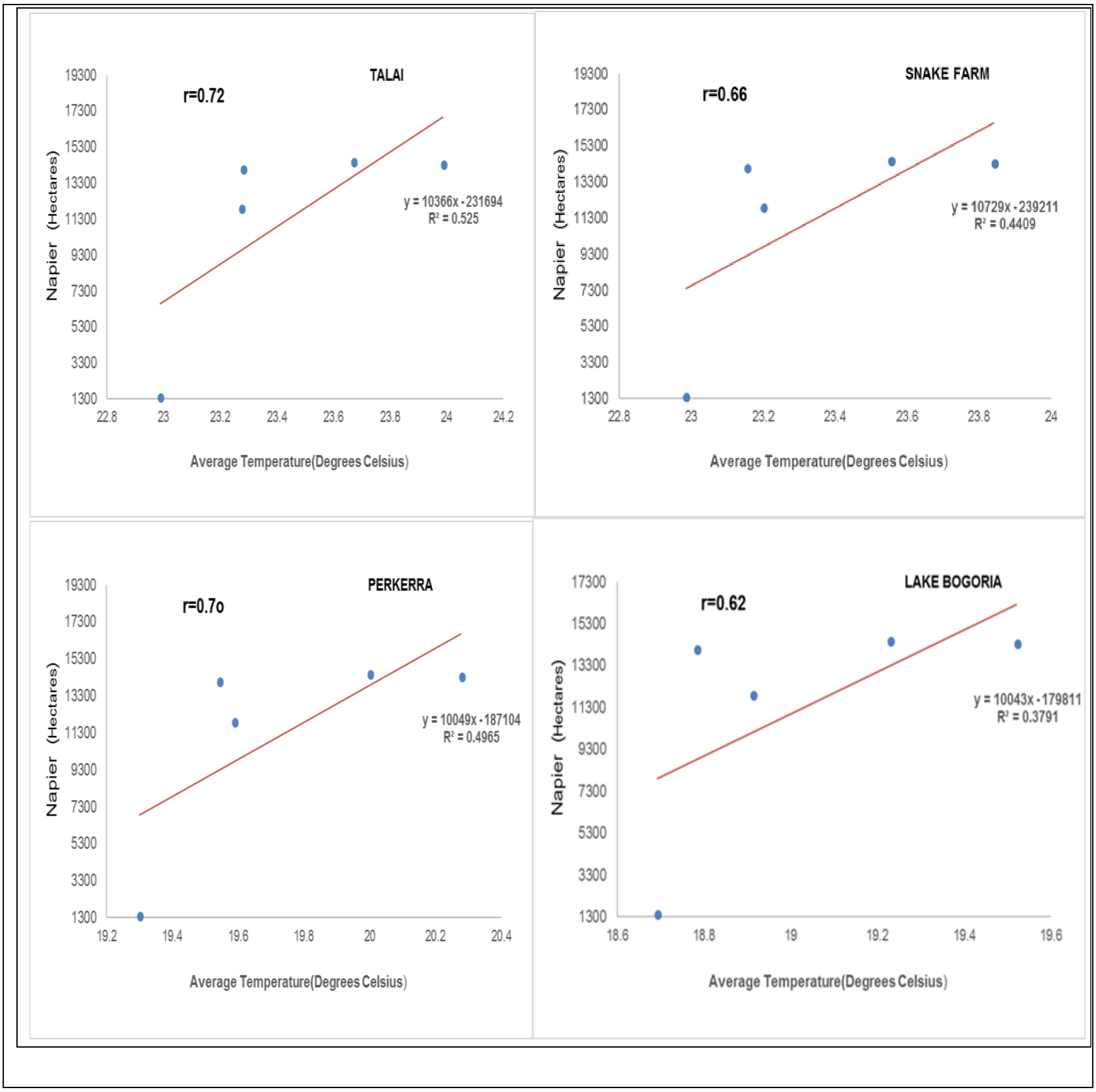


Figure 4.14: The annual maximum and minimum temperatures for the four station in Baringo County

Source: Climatic Research Unit at the University of East Anglia (2016)

The trends in Figure 4.14 shows overlap in both the annual maximum and minimum temperatures of the stations. The highest maximum temperatures are recorded at Snake Farm and Perkerra Station (30-32°C).

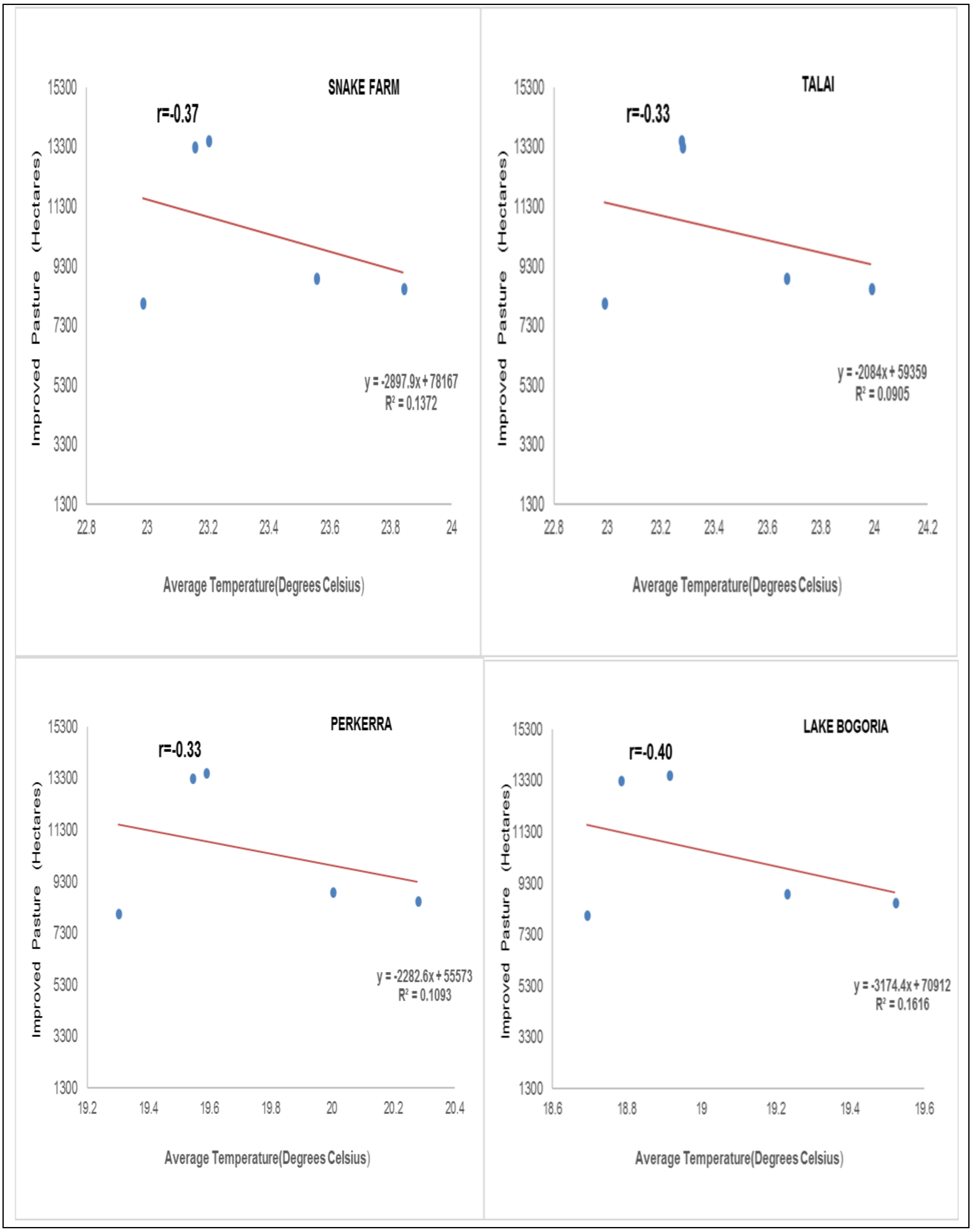
Figure 4.15a and 4.15b is a scatter plot diagram showing the impact of the average air temperature experienced in areas covered by Talai, Snake Farm, Perkerra and Lake Bogoria on number of hectares of Napier and improved pasture developed in Baringo County, which impact on livestock production within the period under review.



Source: GOK (2009) Ministry of Livestock Development. Livestock Production Annual Report. Rift Valley, Kenya

Figure 4.15a: Scatter diagrams for the hectares of Napier development in Baringo County

There is a positive relationship between the number of Napier hectares established and average temperatures experienced (Figure 4,15c). The area covered by Talai Weather Station shows the strongest relationship at r=0.72 unlike the other stations Snake Farm, Perkerra and Lake Bogoria reporting r=0.66, r=0.70 and r=0.62. Also, the R^2 of the regression lines in all the stations and their p-values ($P< 0.05$) show that they are statistically significant. Based on the fact that correlation coefficient measures the strength and direction of a relationship of two variables. For this case all the relationships in Figure 4,15a are positive relationships which are very strong in Talai and Perkerra while moderate in Snake Farm and Lake Bogoria. This implies that the size of land established with Napier increases as average temperature increases.



Source: GOK 2009 Ministry of Livestock Development. Livestock Production Annual Report. Rift Valley, Kenya

Figure 4.15b: Scatter diagrams for the hectares of improved pasture development in Baringo County

Figure 4.15b demonstrates a negative relationship between the number of improved pasture hectares established and the average temperatures recorded in all the areas covered by the four stations. The R^2 in all the stations and the p-value of the trends ($p>0.05$) are not statistically significant.

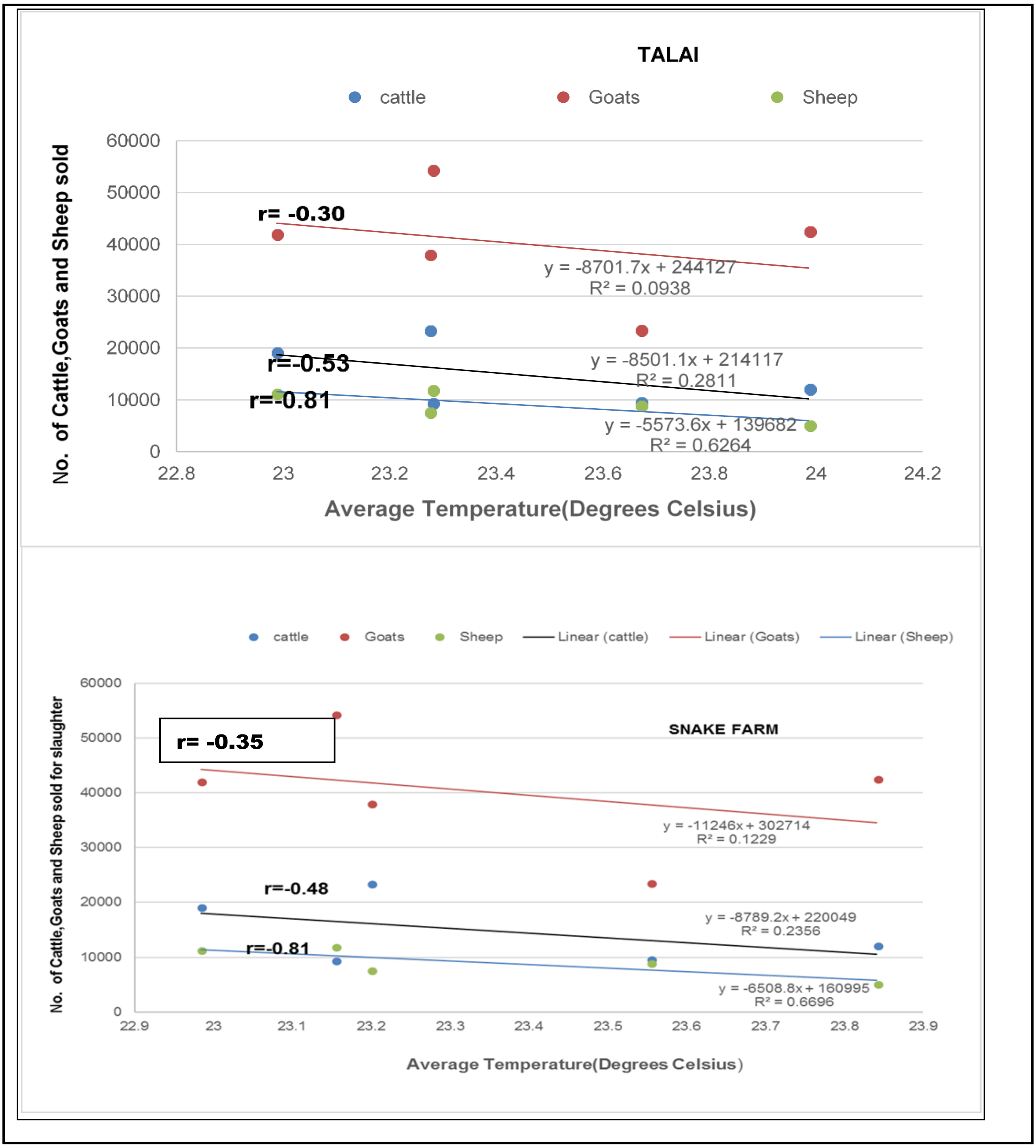


Figure 4.16a: Scatter diagrams and regression line for the quantity of cattle, goat and sheep sold for slaughter in Baringo County

Source: GOK (2009) Ministry of Livestock Development, Livestock Production Annual Report. Rift Valley, Kenya

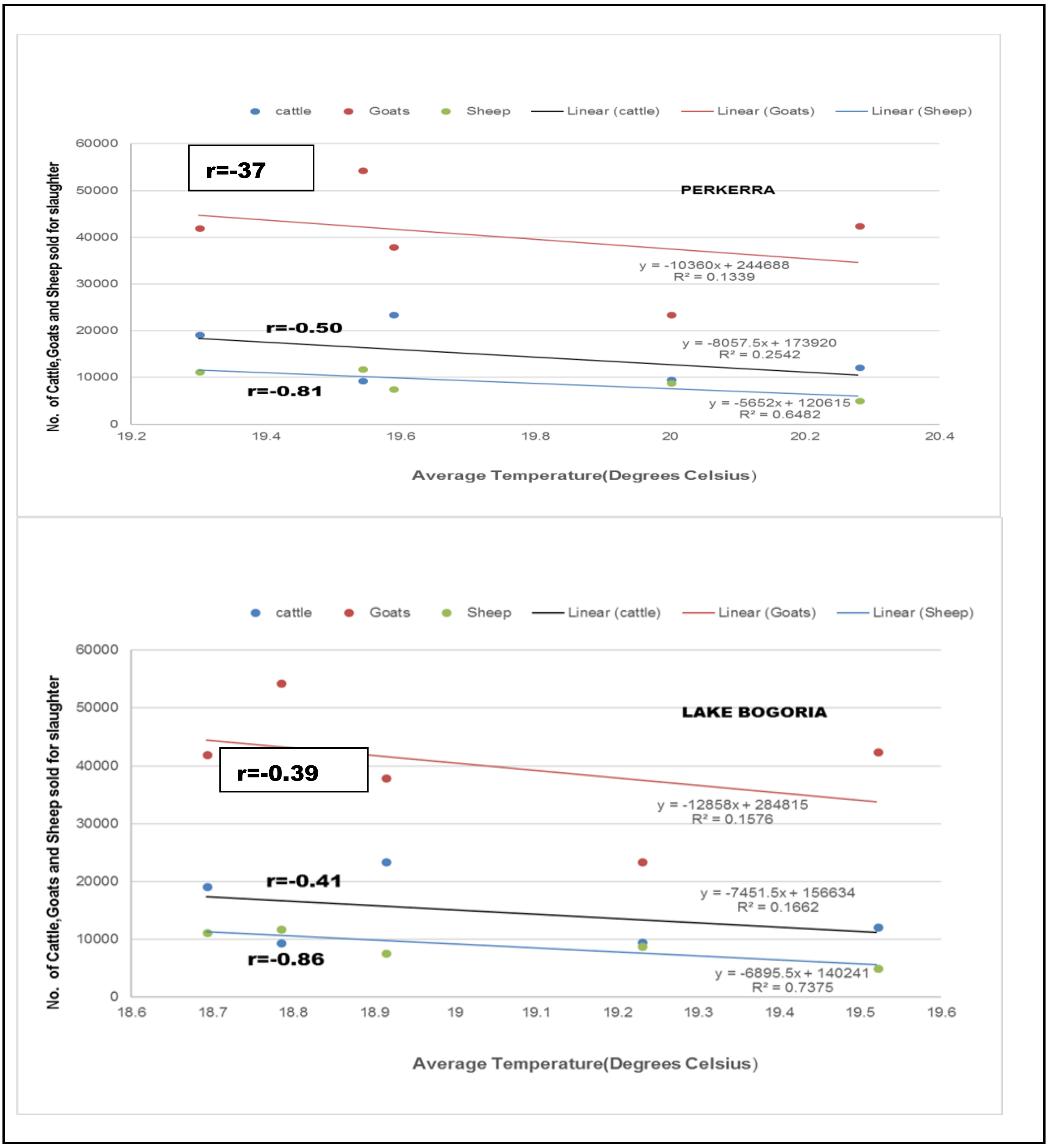


Figure 4.16b: Scatter diagrams and regression lines for the quantity of cattle, goat and sheep sold for slaughter in Baringo County

Source: GOK 2009 Ministry of Livestock Development, Livestock Production Annual Report, Rift Valley, Kenya

Figure 4.16a and 4.16b above demonstrate negative correlation for quantity of cattle, goats and sheep sold for slaughter and average temperature for the areas covered by four weather stations, namely, Talai, Snake Farm, Perkerra and Lake Bogoria. However, the p-values of the trends ($p>0.05$) reflects that the relationships are not statistically significant.

4.3 Discussion

The estimated mean areal precipitation trend by use of average method for four weather stations within the study area (Snake Farm, Kimose Agricultural Holding Ground, Lake Bogoria National Reserve and Perkerra Agricultural Research (Figure 4.2), corroborates Lelenguyah (2013) findings that Baringo South/Marigat has been experiencing an oscillating trend in rainfall with a significant peak observed in 1977. Other observable peaks are those of 1988-89 and 1997-98 from 1971-2007. These are the four major peaks with the highest amounts of rainfall over the last four decades. It is worth noting that the area has been receiving heavy rainfall in every ten years over 1971-2010 periods. Also, this study finding agrees with Ochieng et al. (2017) who reported a declining long-term seasonal rainfall trend in the drylands of Baringo County. Further, Wakachala et al. (2015) reported a decreasing trend in annual rainfall during March-April-May season and high variability within seasons in the Great Rift Valley of Kenya.

Although the study area has been experiencing an oscillating trend in rainfall, it is important to note that, the amount of annual average rainfall has been decreasing with time (Figures 4.2 to 4.4). It is perhaps associated with the aspect of climate change and variability. Figure 4.3 shows an estimated mean areal precipitation trend by use of Theissen polygon method for six weather stations, from 1974-2003. The trend of variation for the amount of rainfall observed annually demonstrates a decrease in the amount rainfall throughout the study period. It corroborates Omoyo et al. (2015) where rainfall trend analysis for 1994–2008 revealed that four of the six weather stations in Machakos County, Kenya were declining up to 3 mm per year. This study finding revealed rainfall decline of up to 4 mm-9.18 mm per year for three stations out of the five stations under review (Table 4.2). A similar study by Mwaura et al. (2017) reported that rainfall in semi-arid Ijara in Garissa, Kenya, has increasingly become uncertain and the trend analyzed using KMD data (40 years period) indicates a definite decline. Recha et al. (2017) also analyzed precipitation data for 10 years in semi-arid Tharaka District, Kenya and reported similar results that showed declining trends between the 1970s and mid-1980s.

The area covered by Lake Bogoria Weather station experienced the largest rainfall variation with at a coefficient of variability (CV) of 30% followed by Snake Farm (29%) and Perkerra 29%. These stations are in the lowlands of Baringo County. The lowest CV was recorded at Chemususu, located in the highlands. The highest mean annual rainfall was recorded at Chemususu and lowest at Perkerra.

Although all the weather stations under review revealed a decline in rainfall trend analysis for the period 1974-2003, Perkerra experienced the highest decline of up to 9.18 mm per year, followed by Chemususu and Snake Farm. However, the trends were not statistically significant except for Perkerra station.

The findings of this study confirm (Luseno., 2003, cited in Galvin et al., 2001) that climatic variability is especially pronounced and crucial in drylands. It also supports Easterling et al. (2000) results of observational studies that suggest that in many areas that have been analysed, changes in total precipitation are amplified at the tails. The findings in this study also corroborate IPCC (2007) who reported that, as climate changes, observations show that changes are occurring in the amount, intensity, frequency and type of precipitation. These aspects of precipitation generally exhibit large natural variability.

The study found that the amount of rainfall experienced within the study period under review had a negative strong relationship with the prices of cattle, goat and sheep. According to Mankiw (2001) the law of supply and demand, states that if all other factors remain equal, the higher the price of a good, the less people will demand that good while the quantity of a good supplied rises as the market price rises and fall as the prices fall. Therefore, for this study the unit price of livestock (cattle, goat and sheep) decreases as the mean areal precipitation increases and *vice versa*, the prices increase as the mean areal precipitation decreases. This is perhaps because, when there is high amount of rainfall the pasture and water for the livestock is available and there is high productivity. During this time the farmers withhold their livestock since they have plenty of food, that leads to low supply of livestock in the market. However, in ASAL the situation is different, pastoralists and agro-pastoralists hold back their livestock since there is adequate food for their families and plenty for their livestock. When there is less mean areal precipitation, there is low supply and the demand is high in the market and eventually the unit price is high.

This finding corroborates Abdow's (2014) argument that the important variables in explaining the average market price of the cattle are: gender; both male and female, age of the cattle; both mature and young, the body condition of the cattle and the season in which the transaction happens. However, this is contradicted by the relationship between the quantity of cattle, goat and sheep sold for slaughter which was $p>0.05$.

According to the livestock farmer, traders, extension agents, abattoirs owners and managers who participated in the FGDs and key informants' interviews in this study, Mogotio and Baringo South Sub-counties in Baringo County experienced a prolonged dry season that never used to be there before. Also, they further claimed that the rainfall pattern has changed and they are unable to predict the seasons as they traditionally used to do long time ago. This argument corroborates Ochieng et al. (2017) findings that, of late, droughts are more frequent in the dry areas of Baringo County, Kenya. This suggests that, climate variability and change is consciously being felt in the study area. Also, the finding agrees with Herrero et al. (2010) that increased drought frequencies to more than a drought every five years could cause major, irreversible decreases in livestock numbers in arid and semi-arid areas.

In the long rainfall season (MAM) the following is experienced by the livestock farmers in the auction sales yard: prices of the livestock increase; there is high demand for young stock; farmers buy young stock for breeding and fattening from the livestock traders; and farmers are not willing sell their livestock. There is plenty of pasture and the livestock show good body condition. This finding corroborates Abdow's (2014) report that highlighted that characteristics that are likely to influence the price of live cattle include; age, sex, grade as well as other related factors such as weather or seasons. According to the participants of the FGDs, during long rainfall season there is more food for the households and little demand for money and therefore many farmers are not willing to sell their livestock.

During the short rainfall season that runs from September-November (SON), the livestock prices are high and thus it is a good time for the farmers to sell their livestock. It is termed as the "field day for farmers". This is because the demand for livestock is high in the sales auction yards. They confirmed that during this season, livestock farmers maximize the sales, categorized as the "best" sales period. The festive season in the month of December which concede with the aforementioned period contributes greatly to the creation of the high demand for livestock species. This finding corroborates the Republic of South Africa (2017) report that in some seasons beef prices were lower due to lower post-holiday demand. The weaned calves (calves are ideally weaned when they are 7 to 8 months old and are completely removed from the mothers and have no more access to the mothers' milk) prices weakened due to lack of demand.

During dry season period there is a high concentration of cattle, sheep and goat in the livestock market (auction sales yard). This implies that, the supply of the aforementioned livestock species is high and consequently the prices are low. The reasons were; the dry season usually commences in January, schools open in January and the parents who are the livestock farmers are to pay school fees and the local consumers have no purchasing power to buy meat due to the live pressure. Therefore, the whole period from January up to March is the "field days of the livestock brokers in the market". However, in conclusion, according to Rajesh et al. (2016) knowledge of seasonal climatic forecast allows farmers and other user of climate information to develop seasonal management strategies learning to potential improvement in the productivity. Although the full potential is yet to be realized, seasonal climate forecast has shown promise in determining planting dates, irrigation needs, crop types, fertilization and planting varieties, expected market condition, pest and disease, and the need for farm insurance for the upcoming season can all be estimated using seasonal forecast.

Figure 4.7 revealed that annual average maximum air temperature experienced in Snake Farm around Lake Baringo and Talai Agricultural Weather Station in Baringo County had variation across the 30 years (1974-2003) period. It also showed that the annual average maximum air temperature is increasing with time. This finding is supported by an FDG discussant who said that, "*the temperatures are increasing day by day and these increases consequently enhance evaporation of water from our few water pans we have around and have brought a lot of diseases to our livestock and human". Further support of the finding came from the stakeholders*" engagement forum where some participants argued that very high temperatures are experienced during the day and unusual cold nights are experienced in the study area. A key informant argued that temperatures are on the rise especially during the day, and that there are serious consequences to these rising temperatures in Baringo County.

The findings (Figure 4.8) indicate that there is a very strong positive relationship between the average amount of rainfall experienced and the number of fodder trees established by the farmers. This implies that the more rain received, the more number of fodder trees established. In the same Figure 4.8, it shows that there is a moderate positive relationship between the natural pasture and the amount of rainfall experienced, while there is a fair relationship between the number of Napier hectares established by the farmers and the amount of rainfall received.

The study findings revealed a very strong positive and statistically significant relationship between the numbers of hectares of Napier established and average air temperature experienced in Talai, followed by Perkerra. This indicated a positive impact of average air temperature on the number of hectares of Napier grown in Baringo County within the period under review. Further, a negative but statistically not significant relationship was reported between improved pasture and average air temperature recorded in Talai, Snake Farm, Perkerra and Lake Bogoria weather stations for the period under review. This demonstrates a negative impact on the number of hectares of improved pasture by the average air temperature experienced in the areas covered by the above-mentioned weather stations. A negative but statistically insignificant relationship was noted between the number of cattle, goats and sheep sold for the slaughter and the average air recorded in Talai, Snake Farm, Perkerra and Lake Baringo.

4.4 Conclusion

Based on the results obtained from use of station average and Theissen method in the estimation of mean areal precipitation in the smaller area (Mogotio and Baringo South Sub-counties) and the larger Baringo County respectively, it was found that there has been a large variation in the amount of rainfall in the years under review. Both methods demonstrated a general decreasing trend in the mean areal precipitation. This was also confirmed by the analysis of annual precipitation trends of the individual stations. For the air temperature, the results revealed an increasing trend and high variation was noted in the maximum and minimum temperatures of most of the stations under review. It was noted that, the dry season occupies the longest period of a year in Baringo County. The amount of rainfall received in the long and short rain seasons is continuously decreasing while the dry spell is increasing. Pastoralists claimed that the rainfall pattern has changed and they are sometimes unable to predict the seasons. They are trying to adapt to these changes by embracing seasonal weather forecast based planning, through Seasonal Rainfall Advisories (SRA) for Baringo Sub-Counties (ASDSP, 2015).

The study finding revealed that a large herd size of livestock per household was a good indicator of pastoralism livelihood in Baringo County. On the impact of the mean areal precipitation variation on the livestock production, among the three species of livestock under review, the sheep population demonstrated a very strong positive association with the amount of rainfall received within the period under review. For the number of hectares of fodder and pasture developed, the result shows that fodder trees yielded the strongest positive association with the mean areal precipitation.

On the impact of the mean areal precipitation variation on the livestock marketing, the price for unit cattle yielded the strongest negative association, while the number of cattle for sold for slaughter demonstrated a strong negative association. Further, the study revealed that preparedness before weather extreme event strikes drought has a positive impact on the performance of livestock marketing.

In conclusion, a strong positive relationship between numbers of hectares of Napier established and air temperature is noted. This implies, as the air temperature increases the number of hectares established with Napier increases too. However, this study also concludes that a negative relationship existed between quantity of sheep sold for slaughter and average air temperature. This implies that the livestock marketing is highly affected by seasonal climate variability represented by air temperature, meaning as the average air temperature decreases the quantity of sheep sold for slaughter increases.

CHAPTER FIVE: UTILITY OF INDIGENOUS AND CONVENTIONAL CLIMATE FORECAST TECHNIQUES

5.1 Introduction

The themes covered in this chapter include; perception of the ASAL communities on Indigenous Traditional Knowledge (ITK) versus conventional (scientific) weather forecast approaches, reliability of ITK versus conventional prediction of climate/weather events, and efficiency and effectiveness of ITK versus conventional approaches to prediction of seasonal climate/weather. All the above-mentioned areas were assessed against livestock production and marketing activities to establish the performance of the two climate forecast approaches used by the ASAL communities in the study area.

5.2 Results

5.2.1 Pastoralists' weather forecast options

Table 5.1 below shows the different options of weather forecast approaches the pastoralists and agro-pastoralists use in making livestock production and marketing decisions in Baringo County. The study findings in Table 5.1 demonstrates that majority (86.6%) of the respondents use both ITK and conventional weather forecast information in making decisions on livestock production and marketing activities in the study area.

Table 5.1: Climate/weather forecasting techniques used by the households

Forecasting Techniques	Frequency	Percent
Indigenous (ITK)	46	11.0
Conventional (Scientific)	43	10.3
Both (ITK and Scientific)	**273**	**86.6**
None	56	13.4

Source: Household survey data (2016)

Plate 5.1 below is an extraction of seasonal rainfall advisories for Baringo Sub-counties. It is a brief document containing the weather predictions for the long rain season, stating what the farmers should do when the rainfall is normal, above normal and below normal. It is an output of stakeholders' engagement where the both ITK and conventional (Scientific) weather forecast are integrated.

Plate 5.1: An extract of seasonal rainfall advisories for Baringo Sub-Counties
Source: ASDSP (2015)

a) Indigenous Traditional Knowledge weather forecast approach

A key informant reported that, the ITK forecasters are diverse in Baringo County e.g. from Iichamus, Pokot and Tugen (Aror, Endorois and Samor) but all eventually converge in their perditions. The Pokots and ILchamus are more precise. However, the study finding from Focus Group Discussions (FGDs) and KIs revealed that the ITK relies on indicators such as the emergence and growth of vegetation/trees, fruiting and flowering. For instance, fig tree, *Balanitis, Boscia angustifolia, Tamarindus indica and Acacia tortilis* their fruiting indicates severe dry season should be expected to occur. Also, the stars and moon interactions i.e. their positions in the sky determine whether there will be rains or not. The “rain makers” know the stars in terms of gender; male and female and also the “red” star. A key informant said, “When the male star is above the female star rain is expected to fall but when the female is above the male no rainfall occur”. The male and female stars are known due to their movements in the sky. From the FGD it was revealed that winds/cyclones are used to predict rains. Wind blowing southwards is an indication of prolonged drought, while the presence of fog or mist in the atmosphere signifies thunderstorm.

Plate 6.1 below shows a demonstration from ITK weather forecaster on how goat entrails are used by the pastoral and agro-pastoral communities in predicting disasters/other events as well as weather prediction.

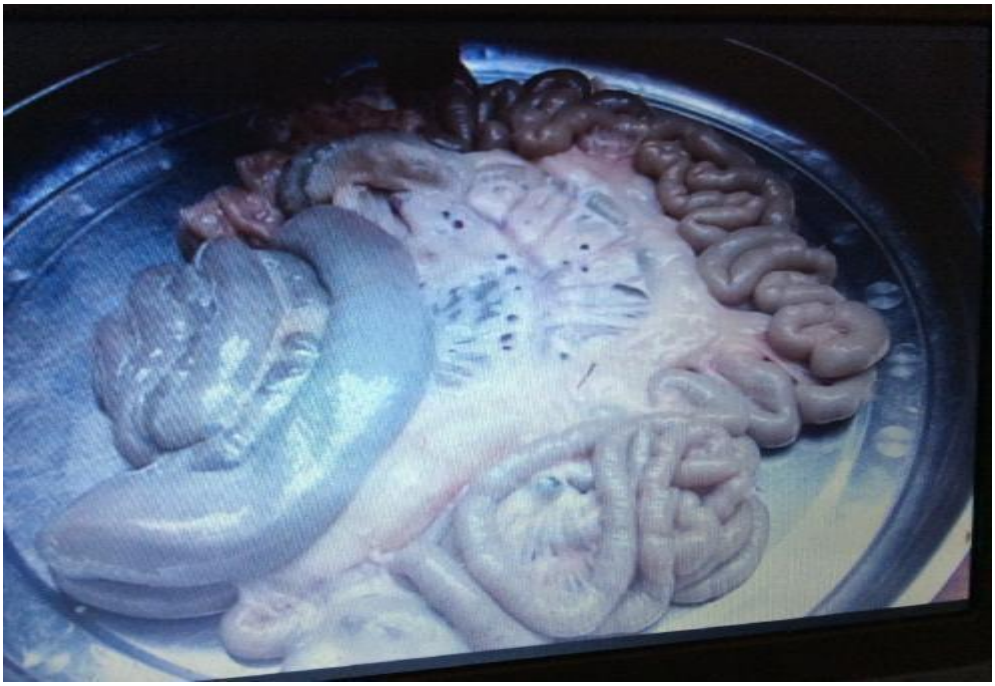


Plate 6.1: Intestines of a goat as an indicator of weather prediction among the ASAL communities in Baringo County is demonstrated in an FDG on 30/8/2016.

Plate 6.1 above shows the intestine of a goat. During an FGD a "rainmaker" demonstrated how the goat intestines are used by the ASAL communities in Baringo County to predict weather. They are able to give seasonal weather forecast advisory services to the communities by interpretation of the goat intestine. The black spots on the clear membrane adjacent to the small intestines signify a disaster and the black spot on the intensity signifies the severity of the disaster. This finding is supported by Ayal et al. (2015) unlike plant-based weather forecasting, only a few indigenous 'experts', called *Uchu*, of Borana communities in Ethiopia are considered to have the skill of reading different signs of animal intestines to forecast weather, social or individual fortunes and the prospect of peace and conflict from local to global levels.

As illustrated in Figure 5.1 and Plate 6.1 from the entrails of a goat the "rain makers" predict other events/ occurrence such as death/disasters, beside rains. Usually reading/interpretation of the intestines is not by one "rain maker" only but all those who are there, each taking his turn to keenly observe and step aside, but later converge to share the knowledge/findings and reveal the prediction. Present in one of the FGD was Baringo County ITK Chair Person who said, “Currently I am training some youngsters/younger generation to take up the mantle”. Also, in Figure 5.1 there is the illustration of ants coming out from an ant hill on the ground, this is an indicator of heavy rainfall. However, a Key informant reported that, although ITK is also accurate their mode of dissemination is poor compared to KMD (conventional) reports.

The findings of this study supported Netshiukhwi et al. (2013) arguments, that the engagement of local communities with the natural environment, are skills not well understood by most scientists, but useful to the farmers. They range from the constellation of stars, animal behavior, cloud cover and type, blossoming of certain indigenous trees, appearance and disappearance of reptiles, to migration of bird species and many others. This expression was enhanced by the focus discussion group where, one of the discussants of an FGD said, “we pastoralist rely on natural happenings, kidding and lamping starts in July-August and September when there is availability of acacia pods, after flowering and they get fruits that contain high crude proteins (CP) content, it enables the animals to come on heat quickly and conceive. The information on when short or long rain season to occur comes from our “rain makers that lives among us”. This finding agrees with the Ajani et al. (2013) that indigenous knowledge practices have been employed in adapting to climate change impacts among farmers in sub-Saharan Africa.

b) Conventional weather forecast approach

From the FGDs and KIs, it was reported that pastoralists and agro-pastoralists generally believe on Kenya Meteorological Department (conventional) on weather forecast more, especially for early warning e.g. for El Niño which they predict accurately. The discussants in the FGDs argued that, though the KMD is generally accurate in weather predictions some “waazees” i.e. the “rain makers” were also accurate. A discussant in one of the FGD said, “The KMD and ITK actually, almost coincide though he prefers the conventional (KMD), due to prediction of intensity”.

c) Blended weather forecast approach

Blended weather forecast approach is derived from the word blend which means mix (a substance) with another substance so that they combine together or a mixture of different substances or other things. It can also be referred to as a hybrid method or integrated weather forecast approach. It involves combination of ITK and conventional (scientific), information and come up with an approach referred to as blended weather forecast. Saima et al. (2015) argued that some researchers extended their knowledge of research in combining different weather forecast approaches to build efficient forecasting models. Many researchers adopted different approaches for improving the accuracy of the model.

The findings of this study from FGDs and KIs showed that, it is paramount to combine the ITK and conventional weather forecast approaches and come up with blended approach that improves the accuracy of the prediction. This was expressed by a KI from ASDSP who said, “We have seasonal climate variability and weather forecast component in our programme of environmental resilience. This corroborates Netshiukhwi et al. (2013) who pointed out that some short-term traditional forecasts/predictions may be successfully merged with science-based climate predictions to enhance the forecast.

ASDSP assists livestock farmers to become resilient to climate change and variability. It brings all stakeholders on board who includes the NDMA, KMD and the ITK experts”. In a forum referred to as participatory scenario planning for climate resilient agricultural livelihoods, all forecasters including Indigenous Technical Knowledge Forecasters (ITF) and Seasonal Climate Forecasters (SCF) by the Kenya Meteorological Services (KMS) endeavor to give accurate and timely information (ASDSP, 2015).

Table 5.2 below presents results on awareness of the existence of blend/mixture of indigenous and conventional weather forecasting techniques in the study area.

Table 5.2: Awareness of blend of ITK and conventional weather forecasting techniques

Awareness status	Frequency	Percent
Aware	127	31.8
Not Aware	**271**	**68.2**

Source: Household survey data (2016)

The findings in Table 5.2 above demonstrated that majority (68.2%) of the respondents are not been aware of the blend/mixture of indigenous and conventional forecasting techniques.

Table 5.3 below shows the reliability of indigenous weather forecast approach in predicting weather in Baringo County. The respondents were required to answer a set of questions whose response was categorized using a 5-point Likert scale; low, fair, good, very good and excellent. The categories, good, very good and excellent were considered to imply that the forecast was reliable while low and fair implied not reliable.

Table 5.3: Reliability of indigenous forecast approach in predicting climate/weather

Climate Events/Features	Percent				
	Low	Fair	Good	Very Good	Excellent
Short-rains season	8.6	18.2	16.3	29.8	27.1
Long-rains season	8.8	24.1	11.0	36.4	19.7
Dry season	8.2	33.3	17.8	24.2	16.4
Rainfall intensity	13.8	15.1	11.5	33.5	26.1
Floods	16.8	12.2	14.9	35.9	20.2
Drought	11	40.4	16.2	19.9	12.5
Rain triggered landslide	17.8	26	17.8	28.8	9.6
Thunder storms	16.9	18.1	20.9	32.2	11.9
Seasonal rain distribution	12.6	18.2	19.0	34.0	16.2
Expected rainfall onset and cessation	15.6	31.9	27.5	16.3	8.8
Temperatures	9.1	15.5	15.8	40.4	19.2
El-Niño	13.4	28.7	14.8	21.5	21.5
La-Niña	13.5	23	21.1	30.5	11.9

Source: Household Survey data (2016)

The study revealed that the ITK weather forecast approach is a reliable means of predicting climate events (Table 5.3). According to 73.2% and 67.1% of the respondents, the ITK weather forecast approach is reliable in predicting both the short-rains and long-rains seasons, respectively (Table 5.3). The weather forecast approach is considered to be a reliable predictor of the rainfall intensity (71.1%) of the respondents, seasonal rainfall distribution (69.2%) as well as temperatures (75.4%). However, majority of the respondents (52.6%) stated that the ITK weather forecast approach is not reliable in predicting the expected rainfall onset and cessation, (58.4%).

Also, the study sought to establish the reliability of ITK indicators in predicting extreme climatic conditions. According to (71.0%) of the respondents, the ITK weather forecast approach is a reliable predictor of floods and thunderstorms (65.0%) as well as El Niño

(57.8%) La- Nina according to 63.5%, and landslides as pointed out by 56.2%. However, majority (51.1%) of the respondents stated that ITK indicators cannot be relied upon in predicting drought. Based on the above mentioned findings, prediction of short rains and long rains and eventually dry season demonstrates the threshold from which livestock production is considered reliable based on ITK predictions.

5.2.2 Pastoralists' views on reliability of conventional weather forecast

Table 5.4 below shows reliability of conventional weather forecast approach in predicting weather in Baringo County. A Likert scale of 5 scores was used to categorise the scores as poor, fair, good, very good and excellent each climate/weather event.

Table 5.4: Reliability of conventional weather forecast in predicting climate/weather

					Percent
Climate Events	Low	Fair	Good	Very Good	Excellent
Short-rains season	8.5	13.5	37.9	35.9	4.2
Long-rains season	5.6	17.2	25.7	32.1	19.4
Rainfall intensity	11.2	14.5	31	26	17.4
Floods	16.9	17.7	26.8	31.5	7.2
Drought	11.6	26.1	27.8	23	11.4
Landslide	13.7	24.9	33.7	22.9	4.7
Thunder storms	10.2	16.5	35.7	28.9	8.7
Seasonal rain distribution	11.9	21.3	28.6	24.6	13.7
Expected rainfall onset and Cessation	13.4	13.4	26.4	30.7	16.1
Temperatures	10.4	22.9	28	26.8	11.8
El-Niño	10.6	18.7	27.7	34.9	8.1
La-Niña	24.4	38.5	22	12.9	2.2

Source: Household survey data (2016)

As indicated in Table 5.4 majority of the respondents pointed out that the conventional weather forecast approach is reliable in predicting long-rains seasons (77.2%), short-rains seasons (78.0%), expected rainfall onset and cessation (73.2%), rainfall intensity (74.4%), seasonal rain distribution (66.9%) as well as temperatures (66.6%). It can also be seen that conventional weather forecast approach is also a reliable predictor of extreme climatic conditions (Table 5.3) According to majority of the respondents the conventional weather forecast approach is reliable in predicting El-Niño (70.7%), floods (65.5%) and thunderstorms (73.3%). However, the study established predictions were not reliable for some climatic conditions namely, la-Niña (62.9%), landslide (38.6%) and drought (37.7%).

5.2.3 Pastoralists' views on reliability of blended conventional and ITK weather forecast

Table 5.5 below shows the results on reliability of blended of conventional and Indigenous weather forecast approach in predicting climatic /weather events (based on paired t-test of the results from Table 5.3 and 5.4) in Baringo County.

Table 5.5: Paired t-test results on reliability of blended conventional and indigenous weather forecast approach in predicting climate /weather

Climate Events	N	T	Df	p-value
Short-rains season	335	4.363	306	**0.000**
Long-rains season	335	-1.328	348	0.185
Rainfall intensity	345	-0.325	213	0.746
Floods	345	4.719	211	**0.000**
Drought	342	-2.547	128	0.012
Landslide	342	1.803	140	0.074
Thunder storms	345	-0.653	155	0.514
Seasonal rain distribution	345	0.097	241	0.922
Expected rainfall onset and	347	-4.002	159	**0.000**
Temperatures	347	1.269	263	0.205
El-Niño	346	-3.663	145	**0.000**
La-Niña	346	8.873	361	**0.000**

Source: Household Survey data (2016)

The study findings revealed that in the short rain season, floods, drought expected rainfall onset and cessation, El-Niño and La-Niña were statistically significant and reflect that there are the weather phenomenon that can best be predicted using the blend of ITK and conventional weather forecasts.

Table 5.6 shows the reliability of the climate /weather forecast approaches reported by the KIs in Baringo County.

Table 5.6: Most reliable climate forecast in the study area by government and its agencies

Type of seasonal climate/weather Forecast	Frequency	Percent
Traditional forecast	2	22
Scientific forecast	3	33
Blend/Mixture of traditional and scientific Forecast	**4**	**45**
Total	**9**	**100**

The majority (45%) of the Government and its agencies staff interviewed reported that the blend/mixture of traditional and conventional forecast is the most reliable weather forecast in the study area as opposed to using the traditional or conventional methods. In support ASDSP (2015) established that the ASAL communities in the Baringo County have been using climate information from both the indigenous and conventional weather forecasters.

The data analyzed for the KIs revealed that, the ITK weather forecast in Baringo County is popular with the communities in the study area because it is understandable (29%), accessible (36%), provided in local language (14%), and practiced by diverse communities (21%) (Table 5.7).

Table 5.7: Why ITK climate forecast is popular with the communities in the study area from the view of the KIs.

Reasons	Frequency	Percent
Understandable i.e. easily interpreted by the local communities	3	29
Accessible to the communities	4	36
Local language used to explain the forecast	1	14
Practiced by diversified communities	2	21
Total	**10**	**100**

Figure 5.1 below shows that majority (42.1%) recognize indigenous climate/weather forecast to have been very efficient relative to conventional forecast in the study area.

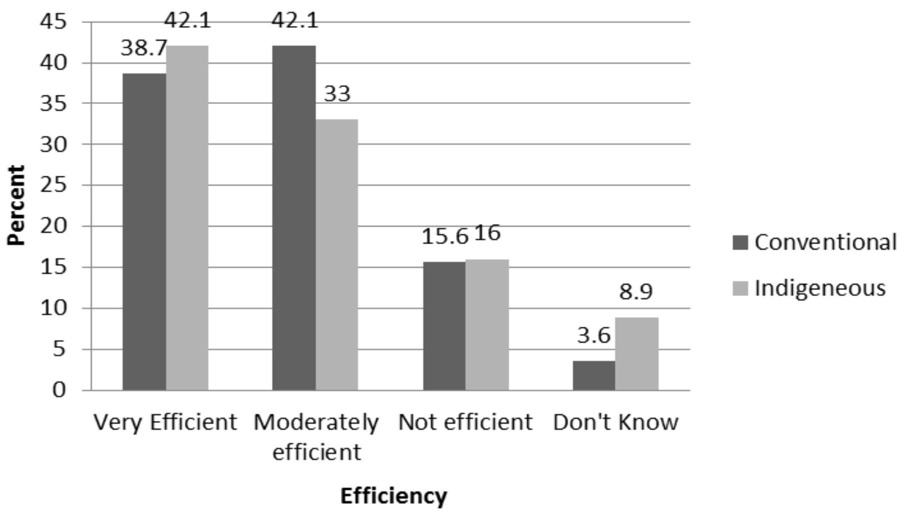


Figure 5.1: Efficiency of indigenous and conventional forecasts
Source: Household survey data (2016)

The Table 5.8 below shows the effectiveness of ITK weather forecast of extreme climatic event in Baringo County.

Table 5.8: Effectiveness of indigenous weather forecast approach on extreme events related to climate variability

Climate Events	Percent			
	No variance	Mild variance	Moderate Variance	High Variance
Seasonal heat stress	42.5	23.4	23.1	11.1
Droughts	47.1	21.6	26	5.3
Flooding	43	26.8	19	11.2
Disease Epidemic	50.7	25.2	16.3	7.8
Feed resource shortage	35.1	25.9	27.4	11.7
Water resource shortage	44.1	24.3	18.2	13.4

Source: Household survey data (2016)

Table 5.8 above indicates that majority (42.5%) of the respondents professed that no variability is observed on the predicted seasonal heat stress from the actual when it is performed by indigenous climate forecasters. Also, majority (47.1%) of the interviewed household heads perceived that, the indigenous climate/weather forecasters are effective in predicting the occurrence of drought with no variability from the actual. Further, a majority portion of the respondents were of the opinion that flooding (43%), disease epidemic (50.7%), feed resource shortage (35.1%) and water resource shortage (44.1%) were well predicted by indigenous climate/weather forecasters, the occurrence having no variability from the actual.

5.3 Discussion

Evaluating the performance of the ITK versus conventional climate or weather forecasts is very challenging because the latter use scientific instruments to predict the weather while the former uses indicators such as trees, stars, animal intestines, winds and others. The majority of the pastoralists and agro-pastoralists were using both ITK and conventional weather forecast information in making decisions on livestock production and marketing activities in Baringo County (Table 5.1).

The finding concurs with information provided by Key Informants (KI) during the survey. Officials from the Agricultural Sector Development Support Programme (ASDSP) and County Meteorological Department incorporate the communities known experts in ITK in weather forecasting in the County through seasonal weather forecast forums referred to as Participatory Scenario Planning (PSP). This is a sectoral participatory forum where they come up with probabilistic forecasts and agro-meteorological advisories. It normally occurs in October every year. The above-mentioned forum usually comes up with Seasonal Rainfall Advisories (SRA) for Baringo Sub-Counties (ASDSP, 2015). The aim of the PSP is to promote the integration of ITK and conventional (scientific) weather forecasting in climate risk management. The role of ASDSP together with CARE International in Kenya (CITK) in the PSP forums is the funding and dissemination of the SRA in collaboration with the relevant ministries in the study area and the entire County (see Plate 5.1).

The PSP forecast has an enhanced sense of ownership by farmers/pastoralists and decision makers, hence contributing to the overwhelming uptake of the disseminated hybrid/integrated forecast. The findings corroborate Glatnz (2003, 2005) and Goddard et al. (2010) arguments that climate scientists are increasingly under pressure to transcend their disciplinary confines and engage in a process of joint, continued and participatory learning with users of the information and to encourage effective outreach programmes for the information to realise its full potential.

Most of the pastoralists and agro-pastoralists have not been aware of the blend/mixture of indigenous and conventional forecasting techniques (Table 5.2). However, this contradicts Table 5.1 where majority reported to have been using both. It is most likely that the pastoralist and agro-pastoralists got these two different weather forecasts from each actor separately unlike in the case of the integrated weather forecast from the ASDSP programme. Therefore, awareness creation of blend/mixture weather forecast technique is required to enhance this new initiative (ASDP, 2015). The finding agrees with Netshiukhwi et al. (2013) who noted that farmers relied almost fully on their experience and traditional knowledge for farming decision making. This finding is further supported by the stakeholders' engagement forum where they recommended up scaling of the integrated seasonal climate forecast in the study area. Also, an FGD discussant said that, "we pastoralist in this area we rely upon ITK weather forecast where animal intestines can predict the weather with the interpretation of our "rainmakers"." On the same notion, a KI reported that the farmers in the study area tend to believe more in ITK more than conventional forecast.

The study has found that the ITK weather forecast approach is a reliable means of predicting the climate event in Baringo County (Table 5.3). The ITK weather forecast approach is reliable in predicting both the short-rains and long-rains seasons respectively. Also, the approach is considered to be a reliable predictor of the rainfall intensity, seasonal rainfall distribution, and temperatures. The finding was supported by an FGD discussant who argued that, although the pastoralists have trust in the ITK weather prediction, it is not that all climate event comes true as they predict, especially so in this era of climate change and variability. This finding supports Madzwamuse's (2010) assertion that local communities must build their resilience by adopting appropriate technologies while making most of traditional knowledge and diversifying their livelihoods to cope with current climate. However, Ayal et al. (2015) reported that herders of Borana communities in Ethiopia made short term weather forecasts using intestinal readings and observed changes in plant and animal body languages. The public confidence in the accuracy of indigenous weather forecasting skills has been gradually eroded overtime due to faulty forecasts. The precision and credibility of the traditional weather forecast steadily declined and led to repeated faulty predictions.

Most of the pastoralists and agro-pastoralist interviewed in the study pointed out that conventional weather forecast approach is reliable in predicting long-rains seasons, short-rains seasons, expected rainfall onset and cessation, rainfall intensity, seasonal rain distribution as well as temperatures (Table 5.4). It can also be seen that the conventional weather forecast approach is also a reliable predictor of extreme climatic conditions in the study area. However, the study established from majority of the respondents that the conventional predictions were not reliable in prediction of, La-Niña, landslide, and drought.

The results presented in Table 5.5 implies that the indigenous and conventional weather forecasts are statistically significant in their effectiveness in predicting short-rains seasons, floods, drought, expected rainfall onset and cessation, El-Niño and La-Niña at 5% levels of significance. For the long-rains seasons, rainfall intensity, landslide, thunderstorms, seasonal rain distribution and temperatures the results are not significant ($p>0.05$). This implies that the integrated indigenous and conventional forecasts are not effective in predicting the above-mentioned climatic events. However, the majority of the Government and its Agencies staff interviewed reported that the blend/mixture of traditional and scientific forecasts is the most reliable weather forecast in the study area. The results indicate, therefore, that more work needs to be done to improve the forecasting of these events.

Most of the pastoralists and agro-pastoralist interviewed in this study reported that the ITK weather forecast was the most efficient among the local communities in Baringo County because it is easily interpreted (Figure 5.1). The finding agrees with Luseno et al. (2003) who noted that pastoralists worldwide rely heavily on indigenous seasonal weather prediction methods, as has been established in this study (Table 5.7) where the majority had an easy access to ITK seasonal climate/weather forecast.

Table 5.8 indicates that majority of the pastoralists and agro-pastoralist professed that no variance is observed between the predicted seasonal heat stresses from the actual when it is performed by indigenous climate forecasters in Baringo County. This implies that the indigenous weather forecast approach is effective for seasonal heat stress prediction. Also, majority of the interviewed pastoralists perceived that the indigenous climate/weather forecasters are effective in predicting the occurrence of drought with no variability from the actual. Further, majority of the respondents alleged that the perdition of climate extreme events of flooding, disease epidemic, feed resource shortage and water resource shortage predicted by indigenous climate/weather forecaster, the occurrence had no variance from the actual.

5.4 Conclusion

The results showed that majority of the communities in the study area had been using both ITK and conventional (scientific) weather forecast information in making decisions on livestock production and marketing. This has been sustained by Agricultural Sector Development Support Programme (ASDSP) who has been working together with Meteorological Development in organizing seasonal weather forecast forums referred Participatory Scenario Planning (PSP). In the forum they bring on board community members known to have experience in ITK weather forecasting such as from the Jamesi, Tugens and Pokot, farmers and other stakeholders. The study revealed that ITK weather forecast approach is reliable in predicting short-rains, long-rains, seasons, rainfall intensity, seasonal rainfall distribution and temperatures. It was found that the indigenous and conventional weather forecasts have statistically significant difference in the effectiveness in predicting short-rains seasons, floods drought expected rainfall onset and cessation, El-Niño and La-Niña. Thus, the ITK weather forecast has been very efficient relative to conventional in the study area. The major reason behind its efficiency is that the majority of the people is able to understand and easily interpreted.

However, although literature have highlighted ITK to have been a common practice by the communities in the ASALs, the findings of these study demonstrates that the blended/integrated is more appropriate to address the shortcomings of ITK and conventional when used separately. Therefore the communities in the ASALs should adopt the blended forecast to reduce the adverse effects of the climate change and variability.

CHAPTER SIX: IMPACT OF INTEGRATED WEATHER FORECASTS TECHNIQUES ON LIVESTOCK PRODUCTION AND MARKETING

6.1 Introduction

The results presented in this chapter responds to objective three of the study. The chapter discusses the impact of indigenous, conventional weather forecast approach on livestock production performance and also on livestock marketing attributes.

6.2 Results

The researcher sought to establish the impacts of the conventional and ITK forecasts on livestock production and marketing decisions. The respondents were required to answer a set of questions whose response was categorized using a 5 - point Likert scale; low, fair, good, very good and excellent. The categories, good, very good and excellent were considered to imply that the forecasts have impacts while low and fair implied that they have no or minimal impacts. The results are presented in Table 6.1 to 6.6 for ITK and conventional impacts, respectively.

6.2.1 ITK forecast on livestock production performance

The Table 6.1 below shows the pastoralists and agro-pastoralists' attitudes on impacts of ITK forecast on livestock production performance in Baringo County.

Table 6.1: Impacts of indigenous weather forecast on livestock production performance

	Percent				
Production Attributes	**Low**	**Fair**	**Good**	**Very Good**	**Excellent**
Milk	19.1	34.4	29.8	8.7	7.9
Growth rate	24.6	25.1	27.4	20.1	2.8
Fertility	20.9	26.6	31.5	15.2	5.7
Calving rate	14.9	20	37.1	21.7	6.3
Calving interval	11.2	26.4	32.3	21.8	8.3

Source: Household Survey data (2016)

Table 6.1 revealed that, majority of the pastoralists and agro-pastoralists interviewed expressed the view that the indigenous knowledge practiced in weather forecasting in Baringo County has impact on the calving rate (65.1%), calving interval (62.4%), fertility (52.4%), growth rate (50.3%) as well as the milk production (46.4%) of their livestock. Although the fertility of livestock is determined by the genetic variation, the feeding has an influence.

Therefore, if the conventional weather forecasts are accurate, the farmer is able to make arrangements on the appropriate time of the year to breed the livestock. If the rains are predicted to be adequate, more pasture and fodder can be established. This finding was supported by the FGD that the indicators for traditional knowledge are embraced in broad terms, relying on the stories and indications from observations and years of experience of their use by the farmers in managing their livestock production and marketing in the study area.

6.2.2 Conventional weather forecast on livestock production performance

Table 6.2 below shows the pastoralists and agro-pastoralists position on the impacts of conventional weather forecast on livestock production performance.

Table 6.2: Impacts of conventional weather forecast on livestock production performance

Production Attributes	Percent				
	Low	**Fair**	**Good**	**Very good**	**Excellent**
Milk	12.2	20.5	22	28.6	16.6
Growth rate	17.8	14.1	16.1	37.8	14.1
Fertility	16.4	17.8	22.2	32.3	11.2
Calving rate	22.9	35.8	20	17.4	3.9
Calving interval	27	33.5	18.2	15.6	5.7

Source: Household survey data (2016)

Table 6.2 above indicates that majority of the respondents interviewed expressed the view that the conventional weather forecast practiced has a positive impact on fertility (65.7%), growth rate (68%) as well as the milk production (67.2%) of their livestock. However, majority of respondents claimed that the conventional weather forecast had no impact on the calving rate (58.7.1%) and calving interval (60.5%). The extension service emphasizes on the conventional weather forecasting, this was reported by a Key Informant who works in the Ministry of Livestock, Agriculture, Fisheries and Irrigation. He said, *"The weather forecast information from the Kenya Meteorological Services and other agencies such as the National Drought Management Authority (NDMA) help us in advising the farmers coping strategies to climate change extreme events such as drought. We are advised on migrations and off-takes when seasonal climate and weather forecasts are below normal, while normal, we are advised some to acquire more animals for fattening and above normal the community will invest in getting more animals to fatten".*

6.2.3 Blended seasonal weather forecasts on livestock production performance

Table 6.3 was generated by a paired-samples t-test to compare the impact of conventional and indigenous weather forecast information on the livestock production performance attributes such as; milk, growth rate, fertility, calving rate and calving interval in Baringo County.

Table 6.3: Impacts of ITK and conventional seasonal weather forecasts approaches on livestock production Performance

Production Attributes	(N)	T	df	p-value
Milk	376	-11.98	375	**0.000**
Growth rate	378	-11.101	377	**0.000**
Fertility	371	-8.806	370	**0.000**
Calving rate	369	6.349	368	**0.000**
Calving interval	368	5.946	367	**0.000**

Source: Household survey data (2016)

The study findings showed that milk, growth rate, fertility, calving rate and calving interval were statistically significant and reflect that the weather phenomenon that can best impact positively on livestock production performance is the use of the blended ITK and conventional weather forecasts. This implies that the integrated indigenous and conventional forecasts have statistically significant difference on the livestock production performance attributes at 5% levels of significance. Had a conventional weather forecast had a positive influence on the livestock calving rate and calving interval performance.

6.2.4 Indigenous weather forecast on livestock marketing performance

Table 6.4 shows respondents' attitudes on the impacts of ITK weather forecasts on marketing attributes in Baringo County.

Table 6.4: Impacts of indigenous weather forecasts on livestock marketing attributes

Marketing Attributes	Percent				
	Low	Fair	Good	Very Good	Excellent
Sales in auction yard	19.9	40.6	26.3	9.4	3.8
Sales outsides the sub-county	28.2	38.5	26	3.5	3.8
Sales	25.7	32.2	25.1	13.2	3.8
Number of livestock sold	32.6	29.7	27.5	7.5	2.7
Purchase of livestock	17.6	29.3	25.4	17.4	10.4
Purchasing price	22	23.3	30.6	13.7	10.4

Source: Household survey data (2016)

According to Table 6.4, significant proportion of the respondents stated that indigenous weather forecasts have a positive impact on livestock marketing attributes that include purchasing price (54.7%), purchase of livestock (53.2%), livestock sales (42.1%), sales in auction yard (39.5%), number of livestock sold (37.7%) and sales outsides the sub-county (33.3%).

6.2.5 Conventional weather forecasts on livestock marketing attributes

Table 6.5 demonstrates the impacts of conventional weather forecasts on marketing attributes.

Table 6.5: Impacts of conventional weather forecasts on marketing attributes

Attributes	Percent				
	Low	Fair	Good	Very Good	Excellent
Sales in auction yard	13	23.6	31.3	21.5	10.6
Sales outsides the sub-county	16.9	15.1	32.5	24.9	10.6
Sales	12.3	29.1	20.9	25.4	12.3
Number of livestock sold	25.4	18.3	31.2	17	8.1
Purchase of livestock	20.4	31.7	28	18.3	1.6
Purchasing price	14.8	29.6	29	23.4	3.2

Source: Household survey data (2016)

The study, through the opinions of respondents, established that conventional weather forecasts have positive impacts on livestock marketing attributes as pointed out by the majority; sales outsides the sub-county (68.0%), sales in auction yard (63.4%), sales (58.6%), number of livestock sold (56.3%), purchasing price (55.6%) as well as the purchase of livestock (47.9%).

6.2.6 Blended seasonal weather forecasts on livestock marketing performance

Table 6.6 shows the relationship between the integrated weather forecast and the livestock marketing performance in Baringo County.

Table 6.6: Paired t-test results on impacts of conventional and indigenous seasonal weather forecasts on livestock marketing performance (paired t-test)

Market Attribute	Mean	t	Df	p-value
Sales in auction yard	355	-10.329	354	0.000
Sales outsides the sub-County	353	-12.6	352	0.000
Sales	354	-10.199	353	0.000
Number of livestock sold	354	-7.319	353	0.000
Purchase of livestock	347	3.787	346	0.000
Purchasing price	347	-0.096	346	0.923

Source: Household survey data (2016)

The findings revealed that all the market attributes except purchasing price (Table 6.6) had a significant relationship with blended ITK and conventional weather forecasts.

6.2.7 Climate/weather forecast on the performance of livestock production and marketing

Table 6.7 was generated from the KI interviews for the purpose of triangulating the results on the impact of weather forecasts on livestock production and marketing. The table shows the effects of using weather forecast on the performance of livestock production and marketing.

Table 6.7: Climate forecast on the performance of livestock production and marketing

Aspect	Frequency	Percent
1. Preparedness in advance before the extreme event strikes has a positive impact on the performance of livestock productivity and Marketing	3.1	31
2. Adequate or inadequate pasture and water as a result of seasonal climate variability has an impact on the performance of livestock productivity and marketing	1.9	19
3. Late arrival or no climate/weather forecast information has an adverse effect on livestock production and marketing	2.5	25
4. Reliable climate /weather forecast information has an impact on the performance of livestock production and marketing	2.5	25
Total	10	100

According to the Table 6.7 above, about 31% of the key informants interviewed reported that the level of the farmer preparedness before weather/climate extreme events strike has a positive impact on the performance of livestock productivity and marketing. This was further supported by findings derived from the Focus Group Discussions on market response to seasonal weather forecast based livestock marketing plan. According to the livestock farmer, traders, extension agents', abattoirs owners and managers in the FGDs as well as key informants of this study reported that in Mogotio and Baringo south sub-counties in Baringo County experience two rainfall seasons and one dry season annually. They are; long rainfall season (March, April and May), short rainfall season (October November and December) and dry season (January-March). They further reported that in the long rainfall season (MAM), the livestock farmers experience the following in the auction sales yard; increase in livestock prices, increased demand for young stock; farmers buy young stock for breeding and fattening from the livestock traders, unwillingness of the farmers to sell their livestock, and lastly increased availability of food for the households and little demand for money.

Also, they argued that, short rainfall season runs from October to December (OND). Within this period the livestock prices are high and at this time, it is good for the farmers to sell their livestock and it is often termed as the "field day for farmers". This is because the demand for livestock is high in the sales auction yards. They confirmed that, during these season livestock farmers maximize the sales, categorized as the "best" sales period. The festival seasons the month of December which concedes with the above-mentioned period contribute greatly in the creation of the high demand of livestock species.

Further, in FGD, it was reported that, during dry season period there is high concentration of cattle, sheep and goat in the livestock market (auction sales yard). This implies that the supply of the above-mentioned livestock species is high and consequently the prices are low. The likely reasons were; the dry season usually commences in January, and this is the time they also open schools. Parents who are the livestock farmers are to pay school fees. During this period and the local consumers have no purchasing power to buy meat due to the livestock pressure. As a result, livestock brokers often benefit from the purchase of livestock; it is their "field days".

6.3 Discussion

The specific objective addressed in this chapter was to establish the impact of both indigenous and conventional seasonal weather forecasts on livestock production and marketing in a changing climate. The findings of this study revealed that ITK weather forecast had a significant positive impact on the calving rate, calving interval, fertility and growth rate of the livestock species (cattle, sheep and goats). This implies that pastoralists and agro-pastoralists perceived that there were benefits in trusting and believing in ITK weather forecasts in practicing livestock production. It is most likely that when the ITK predict above normal in rainfall or otherwise it actually happens and since the pastoralists trust and believe it they adjust and organize the livestock breeding programmes appropriately. However, this study finding showed a difference from the way they perceived conventional forecasts, which had a significant positive impact only on fertility, growth rate and milk production. However, Ayal et al. (2015) argued that the precision and reliability of the forecasting system determines its creditability and acceptance by the users to proactively it in the decision making they make based on the forecasted information. It has been postulated that traditional weather forecasting systems are becoming less reliable due to repeated faulty forecasts.

For the blended weather forecast integrating both ITK and Convectional, perceived that the milk, growth rate, fertility, calving rate and interval are statistically significant and reflect the weather phenomenon that can best impact positively on livestock production performance. This finding supports Berkes (2009) that scholars waste too much time and efforts on a science versus traditional knowledge debate; thus the need for reframing it instead a science and traditional knowledge dialogue and partnership. Netshiukhwi et al. (2013) supports Berkes' argument, in that the complications of a changing climate make dialogue/partnership a necessity.

For the marketing, the pastoralists and agro-pastoralists perceived that conventional forecasts had higher positive impact on marketing attributes than ITK (Table 6.5). This implies that they trust and believe in conventional forecast on livestock marketing aspects. This trust is possibly due to the dynamics of the market in the face of digital migration in sales, for instance, the use of "Mpesa" transactions in sales. Also convectional forecasts can be digitized to be used in the mobile phones. The highest positive impact is observed in the sales of livestock to the buyers from outside of Baringo County. This contributes to the advancement in networking due to improved communication by use of mobile phones applications. It also reflects adoption of seasonal weather forecast based planning/management by the business communities. They follow the calendar of season's weather forecast i.e. long and short rains and dry seasons, since the livestock markets in the study area exhibit different categories of livestock depending on the season. For blended seasonal weather forecasts, it is perceived that all the market attributes except purchasing price have a significant relationship (Table 6.6).

6.4 Conclusion

In conclusion, the ITK weather forecast has positive impact on the livestock production performance in the aspect of calving rate, calving interval, fertility, and growth rate and milk production. However, a number of pastoral communities in the study area relied on extension agents who emphasize on conventional weather forecast advisory services. The study further revealed that the calving rate and calving interval performance are more positively impacted by the information obtained from conventional weather forecast.

For livestock marketing, both the ITK and the conventional had an impact on the purchasing price, purchase of livestock, livestock sales volumes, sales in the auction yard, number of livestock sold, and sale outside the sub-county. Further, the study showed that there is a significant difference in the impacts of ITK and conventional weather forecast on livestock production and marketing decisions in the study area. It also revealed that Baringo County experiences two rainfall and one dry seasons. They include; long rainfall season (March, April and May), short rainfall season (October November and December) and dry season January-March parts of June-September, which cover the biggest portion of the year. In long rains, high prices for livestock are offered in reciprocate to high demand for of young stock. During the short rains, the prices are high which is "field day for farmers". Eventually at dry period the prices of livestock are low due to high supply in the auction yard.

CHAPTER SEVEN: EFFECTIVE CLIMATE FORECAST SYTEM FOR SUSTAINABLE LIVESTOCK PRODUCTION AND MARKETING

7.1 Introduction

This chapter describes and presents the stakeholders opinions on effective climate forecast system for sustainable livestock production and marketing. The opinions of the stakeholders were enhanced with the survey results crowning the triangulation aspect of the study findings. The focus is to address objective four: to recommend intervention to enhance efficiency and effectiveness in livestock production and marketing in the context of climate change.

Despite the presence of the adverse effects of climate change and variability, the ASAL communities in Baringo County continue to rely on livestock for their livelihood. This chapter further describes the sustainability of livestock production and marketing among the pastoral and agro-pastoral communities residing within the drylands of Baringo County in the face of changing climate and variability. The stakeholders, survey respondents, FGD and KI recommendations are described to enhance effectiveness and efficiency of livestock production and marketing in the context of climate change

7.2 Results

7.2.1 Stakeholders engagement on recommendation/interventions

Figure 7.1 below shows a Transdisciplinary Approach (TDA) to climate change and variability framework developed out of the stakeholders' engagement, for recommending interventions to enhance efficiency and effectiveness in livestock production and marketing in the face of climate change in Baringo. To achieve this, as shown in the portion "A" of the framework, a non-academic environment was created, a "stakeholders' engagement" where the different disciplines/ stakeholders were brought on board, discussed and they came up with recommendation/ intervention themselves. They included representatives of: Extension staff from Ministry of Agriculture, Livestock, Fisheries and Irrigation, Agricultural Sector Development Support Programme (ASDP), Kerio Valley Development Authority, Livestock Marketing Association, Abattoir Owners, Freelance Livestock Traders, Pastoralists, Agro-pastoralists, Lake Bogoria Basin Development Authority, Ministry of Co-operative

Development, World Vision (NGO), Baringo County Revenue Department, Baringo County Meteorological Department, National Drought Management Authority, Kenya Agricultural Research Organization (KALRO) and Kenya Commercial Bank (KCB).

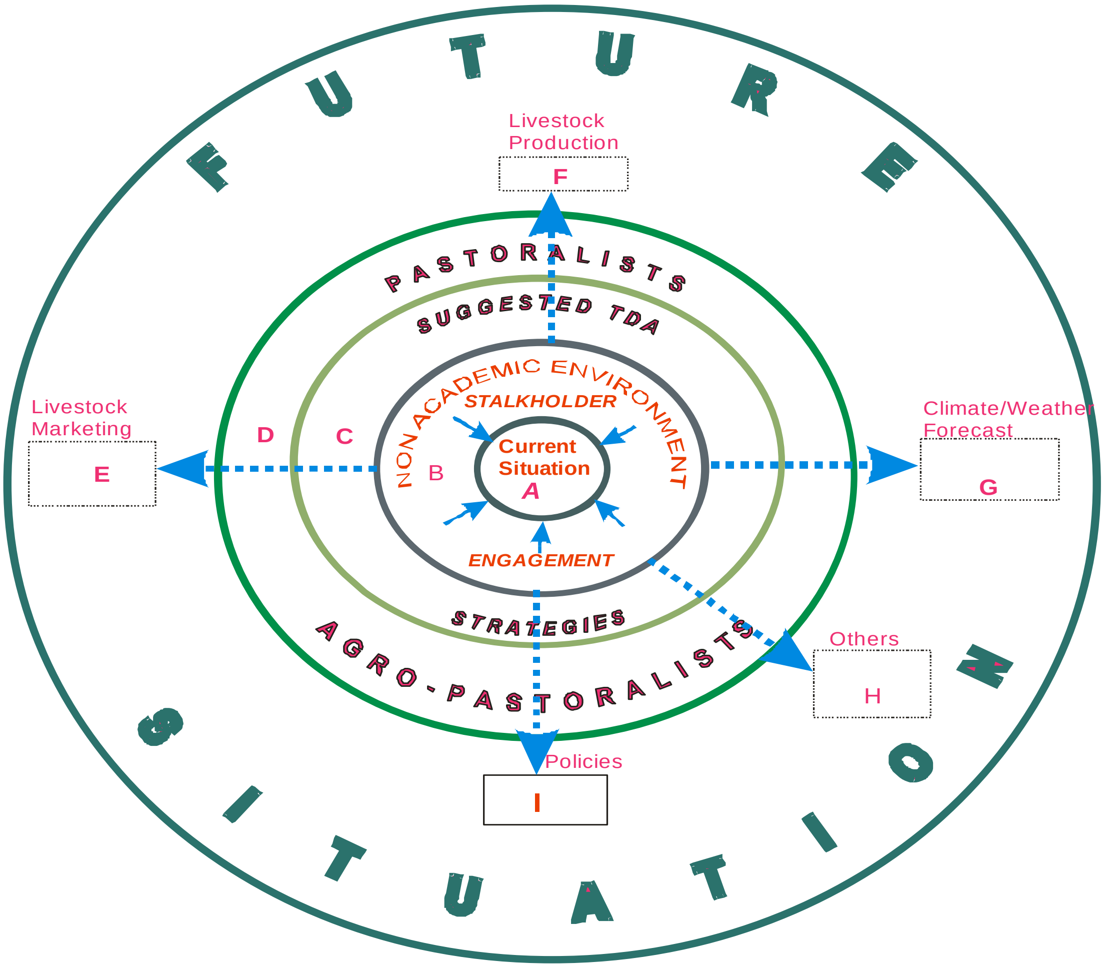


Figure 7.1: Transdisciplinary Approach to climate change framework for Baringo County
Source: Author 2016

Key for the framework:

A– Current situation that requires to be changed. The identified gap existing is that the livestock farmers are practicing production without sufficient and accurate weather/climate forecast and operating in a disorganized livestock market in the face of climate change and variability. The problems identified by the stakeholders are elaborated and discussed (see section 7.3).

B- Mapping of the stakeholders and engaging them in solving the identified problems by coming up with recommendations for interventions, using participatory approaches (see section 7.3).

C-Future situation that shall be achieved through suggested Transdisciplinary Approach (see section 7.3).

D-Pastoralists and agro-pastoralist communities in Baringo County in the face of climate change (implementation of strategies), (see section 7.3).

E-I List of suggested TDA recommended strategies to address livestock marketing, production, climate/weather forecast, others and policies (see sections 7.3.1-7.3.6).

7.2.2 Survey results on recommendation/interventions

The six adaptation strategies reported include breeding, disease and disease control, feed management, etc. Table 7.1 below demonstrated that a significant proportion 32.84% of the respondents reported that they control breeding of their livestock as a means of averting adverse impacts of seasonal climate variability. The least preferred was alternative farming 5.39%

Table 7.1: Farmers' means of averting adverse impacts of seasonal climate variability on livestock production practices/system

Suggestions/Adaptation strategy	Frequency	Percentage
Breeding	67	**32.84**
Disaster and disease control	49	24.02
Feed management	36	17.65
Herd size management	23	11.27
Information access	18	8.82
Alternative farming	11	5.39
Total	**204**	**100.00**

Source: Household survey data 2016

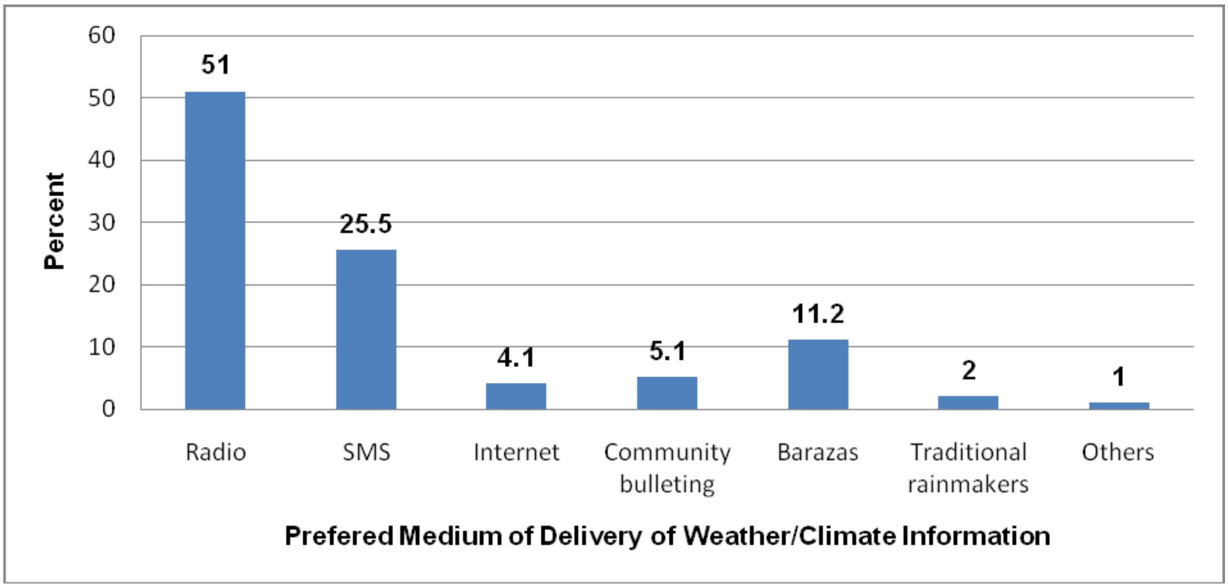
Table 7.2 below shows majority (82.1%) apply the weather forecast information on cessation of rainfall to manage their livestock production and marketing activities.

Table 7.2: Applicability of weather forecasting on livestock production and marketing based on the predicted climatic events

Climatic events	Applicable	Not Applicable
On-set of rains	79.2	20.8
Cessation of rains	**82.1**	17.9
Flood forecasts	67.1	32.9
Drought forecast	75.8	24.2

Source: Household survey data (2016)

Figure 7.2 below indicates that a majority (51%) of the respondents use the radio as medium of getting the weather and climate information for use in livestock production and marketing.



Source: Household survey data (2016)

Figure 7.2: Medium of delivery of weather and climate information for use in livestock production and marketing

Table 7.3 below shows the possible opportunities brought about by climate variability to the pastoralists and agro-pastoralists. They include variation in livestock production trends depending on climate variation. The farmers should seize this opportunity for better prices of their livestock products. There could be deficit in the supply of livestock which the farmer should capitalize on for more production. Climate variability can also create a market for value added goods from the farmers. Based on the study findings, a proposition of (31.07%) of respondents reported fluctuation of the livestock production especially during prolonged dry period. Further, it was coincidentally reported by 42.97% respondents that the context of climate variability creates a demand for livestock value chain products such as meat and milk.

Table 7.3: Opportunities in livestock production and marketing in the context of climate variability

Opportunities in livestock production	Frequency	Percentage
Fluctuation in livestock production	32	31.07
Improved infrastructure	25	24.27
Quality improve Increased production period	18	17.48
Increased production period	28	27.18
Total	103	100
Opportunities in livestock marketing		
Creation of demand for livestock value chain products	55	42.97
Diverse practices	17	13.28
Source of government revenue	15	11.72
Value addition	19	14.84
Increased trading activities	22	17.9
Total	**128**	**100**

Source: Household survey data (2016)

Figure 7.3 shows that the majority (51%) of the respondents are willing to pay for the weather/climatic information which they can use in planning for their livestock production and marketing.

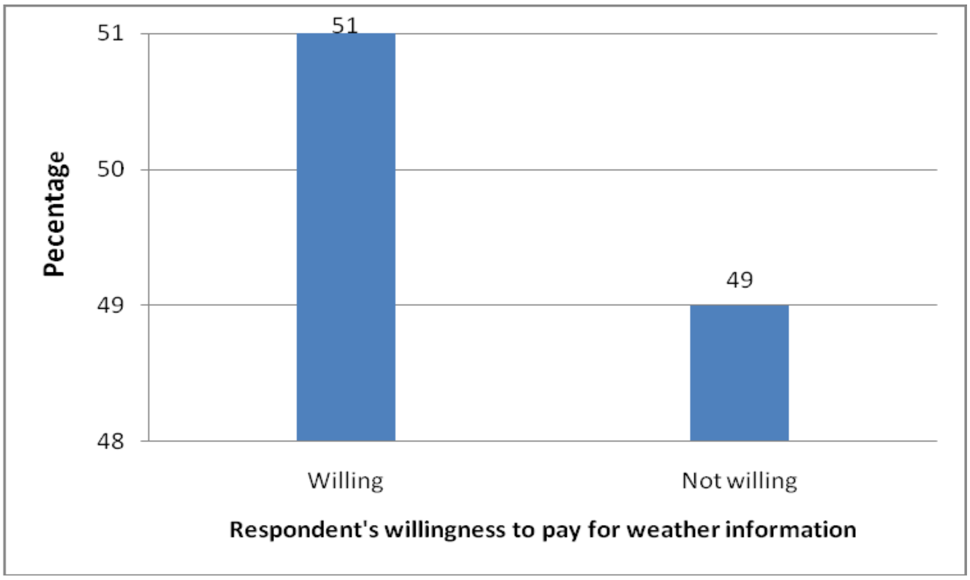


Figure 7.3: Willingness of the respondent to pay for weather /climate information

Source: Household survey data (2016)

Table 7.4: Respondents’ suggestions on improvement of reliability of climate forecast

Respondents suggestions to improve the reliability of the traditional indigenous knowledge weather forecast		
	Frequency	**Percentage**
Training farmers on importance of weather forecast information	15	15.46
Government involvement both in ITK and conventional forecast	34	35.05
Recognition of ITK weather men by Government	12	12.37
Total	**97**	**100**
Respondents’ suggestions to improve the reliability of the convectional (scientific) weather forecast		
	Frequency	**Percentage**
Access to information	14	32.56
Training farmers in interpretation of weather information	12	27.91
Accurate data for specific regions	9	20.93
Presentation of weather data to farmers	8	18.60
Total	**43**	**100**

Source: Household survey data

Table 7.4 shows that (35.05%) and (32.56%) of the respondents had the opinion that government involvement for both in ITK and conventional weather forecasts and farmers access to information, respectively, will improve the reliability of ITK and conventional (scientific) weather forecasts. The frequencies of Table 7.4 and 7.5 demonstrate the response of the respondents for two particular questions in the interview schedule. They further show that, only few respondents who responded out of 437 respondents. However, the questions in the interview schedule (see Appendix 1) had different response rates.

Table 7.5 Respondents' suggestions to reduce adverse impact on livestock production and marketing

Respondents' suggestion to reduce adverse impact on livestock production and marketing by use of ITK weather forecast		
Respondents' suggestion	**Frequency**	**Percentage**
Dissemination of information	31	**44.93**
Training	25	36.23
Deployment of extension weather officers	13	18.84
Total	**69**	**100**

Respondents' Suggestion to reduce adverse impacts on livestock production and marketing by use of Conventional Weather Forecast		
	Frequency	**Percentage**
Dissemination of information	28	41.18
Education/Training	24	35.29
Sensitization on adverse weather condition	16	23.53
Total	**68**	**100.0**

Table 7.5 demonstrates the respondents' suggestion towards reduction of adverse impacts on livestock production and marketing by use of ITK and conventional (scientific) weather forecast respectively. The majority (44.93%) and (41.18%), respectively, suggested that the pathways used in the dissemination of information on the weather forecast will reduce the adverse impacts on livestock production and marketing. Examples of suggested pathways given out in the FGDs were; simplified radio programmes using local language and Ministry of Agriculture, Livestock, Fisheries and Irrigation extension staff to disseminate weather information in a local language that the community can understand.

Table 7.6 below shows majority of the respondents would wish to receive weather/climate information forecasts on on-set of rains (82.1%), floods (67.1%), drought (75.8%) and cessation (82.1) of rains, respectively.

Table 7.6: Weather/climate information that livestock farmers would wish to receive

Weather/climate information Forecasts	Response	Frequency	Percent
	Yes	340	**82.1**
On-set of rains	No	74	17.9
	Total	**414**	**100.0**
	Yes	277	**67.1**
Flood	No	136	32.9
	Total	**413**	**100.0**
	Yes	314	**75.8**
Drought	No	100	24.2
	Total	**414**	**100.0**
	Yes	340	**82.1**
Cessation of rains	No	74	17.9
	Total	**414**	**100.0**
	Yes	155	47.4
Others	No	172	**52.6**
	Total	**327**	**100.0**

Source: Household survey data (2016)

7.3 Discussion

The stakeholders' framework was developed to integrate a transdisciplinary (TD) approach in the study, where stakeholders had different frames of the reference concerning the problems the community is experiencing in regards to climate change and variability (Figure7.1). The current situation was discussed in detail in relation to climate change and variability as well as the problems that are associated with it in Baringo County. The following were the problems identified shown in Figure 7.4. They discussed the problems in four dimensions: weather, livestock production and marketing, livelihoods, and diseases and security. The farmers claimed that they are practicing livestock production and marketing without sufficient and accurate climate /weather forecast. The ITK that they used to rely on seem to have been overtaken by time in the era of climate change and variability. However, they reported that they are not able to interpret and understand the conventional weather forecast. A discussant in one of the FGD said, "the conventional forecast should be translated in our local language or simplified for local farmers to understand".

In their deliberation it also came out that there had been frequent outbreak of human and livestock diseases. The argument was that very high day temperatures and extreme cold nights are being experienced. Also, extreme events such as floods, prolonged drought and heat waves are being witnessed more frequently than before. This situation has contributed to the emergence of pest and diseases such as East Coast Fever, lumpy skin for small stock Contagious Caprine Pleuropneumonia (CCPP) and Prion disease (PRP). This finding supports Amadi et al. (2018) who reported on climatic hazards associated with climate change and variability such as floods, heat stress, heavy rainfall, changes in temperatures that have contributed to the increase of malaria transmission among the communities in Baringo County.

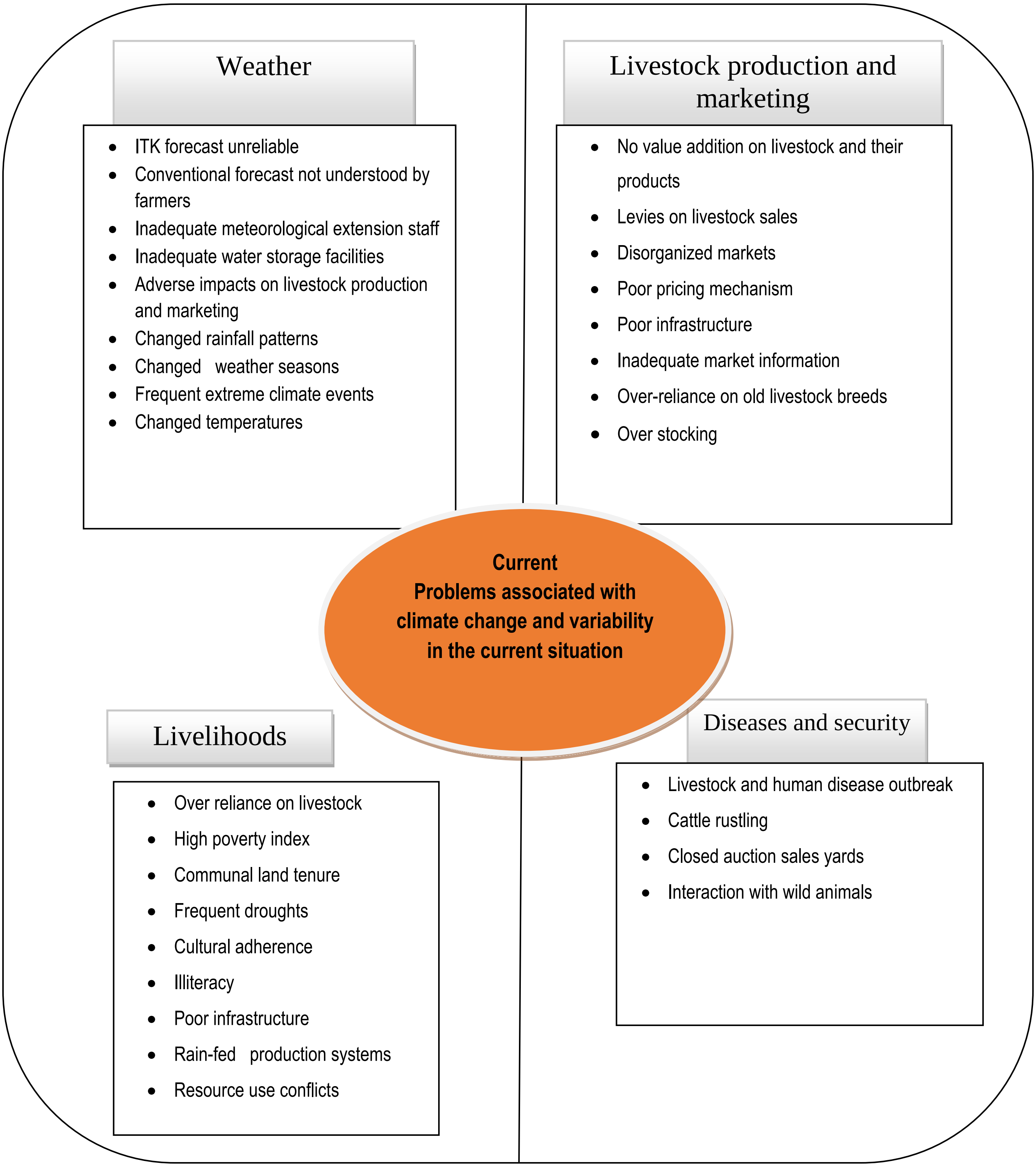


Figure 7.4: Stakeholders' identified problems associated with climate change and variability in the ASAL parts of Baringo County

7.3.1 Livestock production

Figure 7.5 below shows the stakeholders' recommendation/interventions to enhance efficiency and effectiveness of livestock production in the future situation for the ASAL parts of Baringo County.

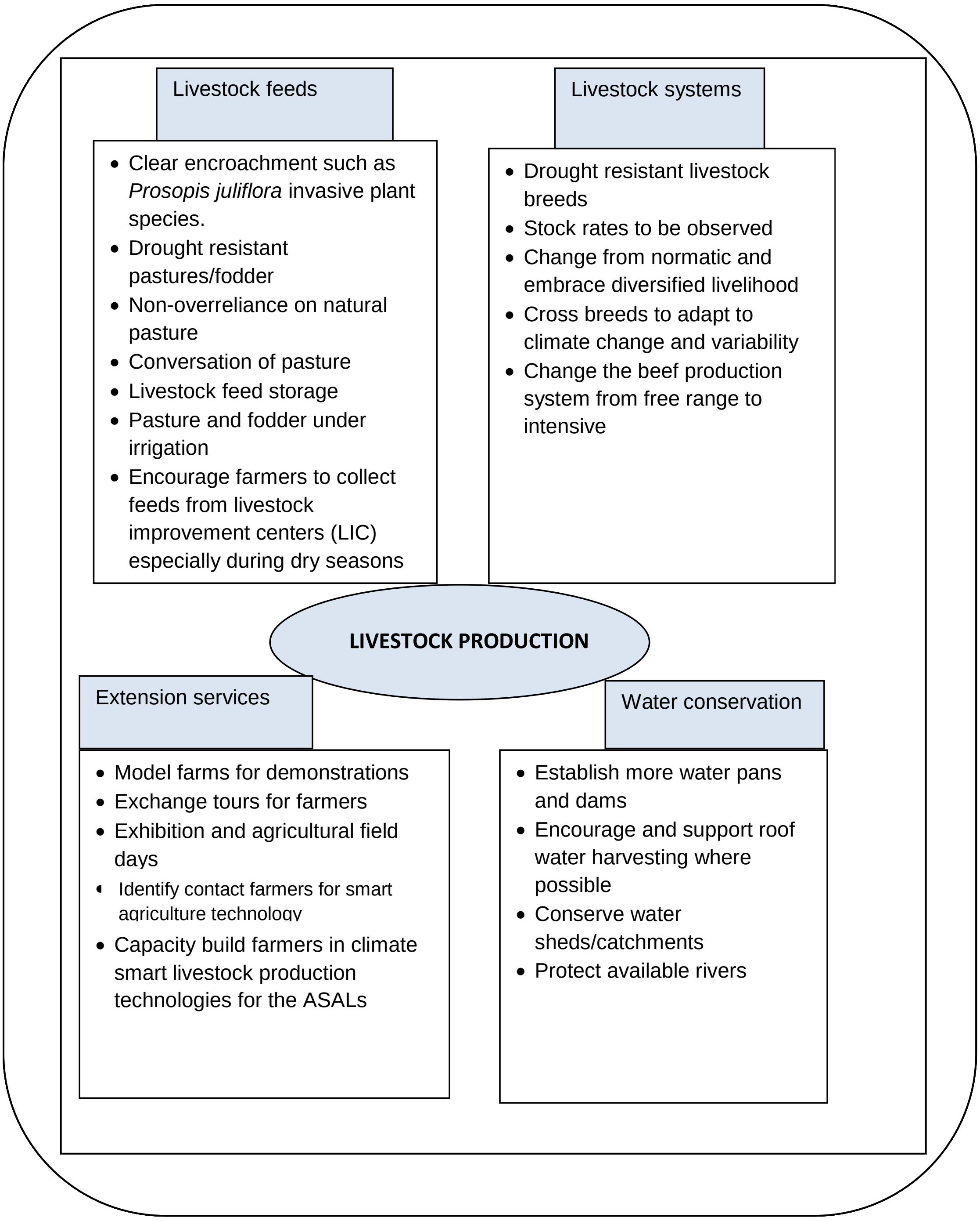


Figure 7.5: Stakeholders' recommendation/interventions for livestock production in the ASAL parts of Baringo County.

The stakeholders' recommendations in Figure 7.5 addresses the following aspects: livestock feeds, livestock system, extension services and water conservation. They felt there was need for adoption of the interventions in the above-mentioned aspects to enhance the efficiency and effectiveness of livestock production. The stakeholders' engagement forum identified livestock feed aspect to be paramount in the face of climate change and variability. This is because of the frequent extreme events such as prolonged droughts that have been occurring in the study area. One Key Informant said, *"we are losing a big number of our livestock during the frequent severe drought season simply because we lack conserved livestock feed. Also, the little pasture that has been there is encroached by the invasive plant".* This observation is supported by the stakeholders' recommendation on the clearance of the encroachment of the *Prosopis juliflora* invasive plant species in order have access to livestock feed to enhance effective and efficient livestock production in the face of climate change variability in Baringo County. This intervention is supported by Amadi et al. (2018) who recommended that local leaders from the lowland zone in Baringo County can get rid of *Prosopis juliflora* from their dwellings as a measure of reducing contact with mosquitoes. This implies that the invasive plant is a social menace to the communities residing in the ASAL parts of Baringo County, although they derive some benefits from it e.g. firewood and feed to small ruminants like sheep and goats.

Under livestock system, the stakeholders' recommended that farmers to adopt drought resistant livestock breeds in order to enhance livestock production in the face of climate change and variability. This recommendation supports Kahi et al. (2006) assertion that animals kept in Kenya's ASALs are the highly adapted indigenous Zebu (small East African zebu and Boran) or exotic beef (for example, Hereford, Simmental, Charolais, Angus) breeds and their crosses kept mainly by the commercial ranchers. Further, a more vibrant extension service that involves creation of models' farms for demonstration and development of more water pans and dams for human and livestock were recommended.

For livestock production in Baringo County, the FGD and KI reported that if the weather prediction is below, normal livestock farmers in Baringo County adopt different coping mechanisms such as migration and off-takes. When rainfall becomes normal, livestock farmers will continue with their normal practices, and some might acquire more animals to fatten. If the prediction is above normal the community will invest in getting more animals to fatten.

7.3.2 Livestock marketing

Also, the stakeholders come up with recommendations/interventions to enhance efficiency and effectiveness of livestock marketing in the face of climate change and variability in the ASAL parts of Baringo County (Figure 7.6).

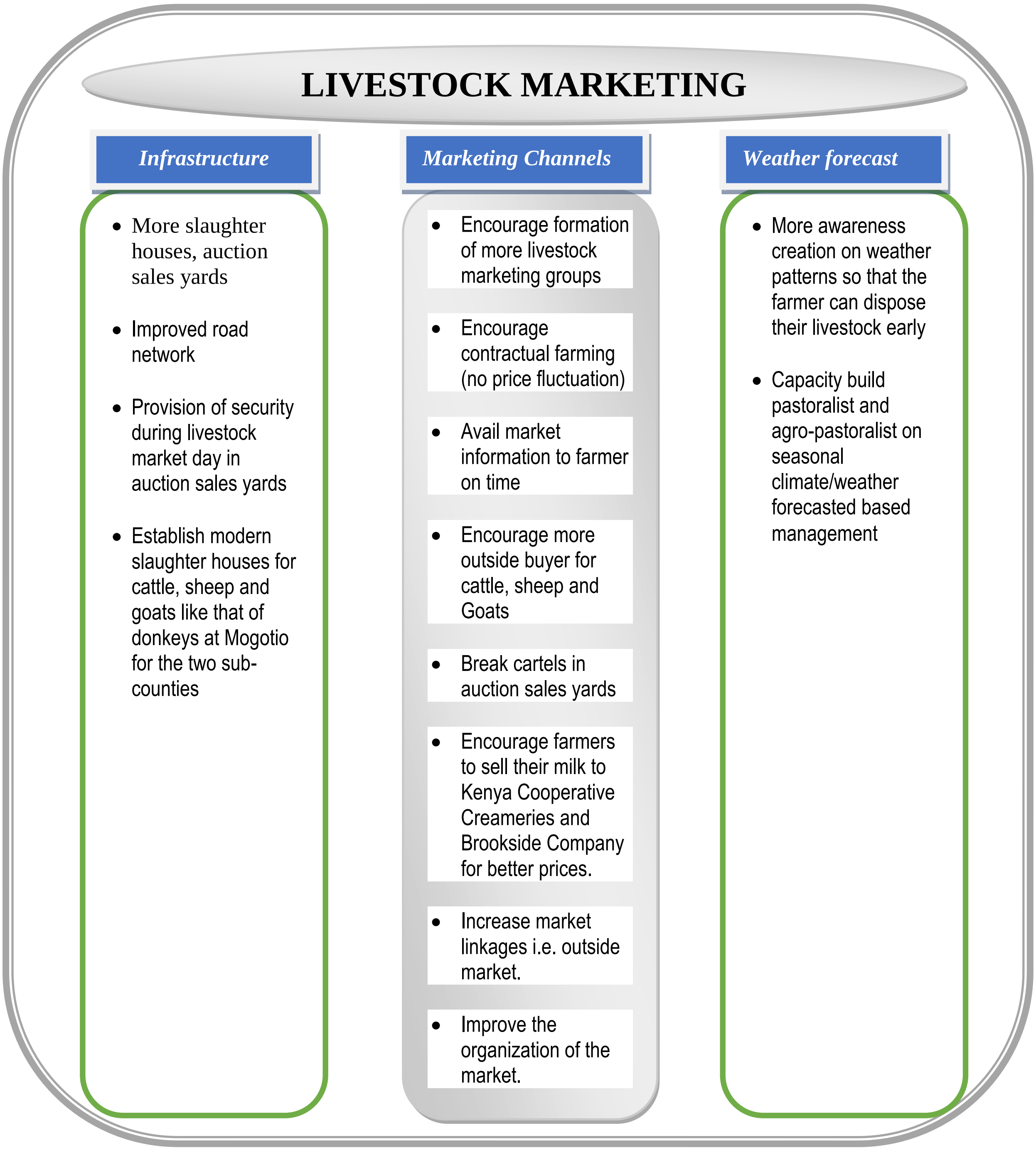


Figure 7.6: Interventions for livestock marketing in the ASAL in Baringo County

Figure 7.6 indicates the stakeholders' recommendations in addressing problems encountered by ASAL communities in livestock marketing in the face of climate change and variability. Three attributes were considered; infrastructure, marketing and weather forecast. It was recommended more slaughter and auction sales yards to be established to accommodate more livestock and reduce long distances the farmers undertake while accessing the auction sales yards. General improvement of the road network will enhance the transport of goods and services to the designated auction sales yards. This recommendation supports Kilung'o and Mghenyi (2001) who observed that the ASALs are characterized by poor infrastructure, road and telecommunication networks installation of these services will open up these areas for development.

Provision of the security during market days in the auction yards is a recommendation supported by an FGD discussant who said, *"Many of our auction sales yards have been closed because of insecurity. Thugs could beat and rob people their money as they come and leave the auction yards".* Farmers were also encouraged, by state to form more livestock marketing groups to enhance their bargaining power to get the best price of their livestock.

More discussion on recommendations/interventions in enhancing the efficiency and effectiveness of livestock marketing in Baringo County were advanced in FGDs and KIs. One of the KI reported that when the weather forecast prediction is below normal, more livestock is brought to the market (auction yards) during this time and the prices are low due to over-supply and emaciated state of the animals. Further, the KI argued that when the weather prediction is above normal or normal, the farmers hold back their animals and they come to the market to acquire more for fattening and the breeding is high at this time since pasture and water are in plenty. Also, a discussant in FGD reported that during the dry spell in January to April the prices of food stuff go up and that of livestock goes down. The emaciated animals and more animals are brought to the market, reflecting high supply and lower demand leading to depressed prices. During this period, no fattening and no breeding animals are brought to the market. The livestock brought to the market during this dry period are only sold for slaughter.

7.3.3 Early warning/weather or climate prediction

Climate information and services was also discussed by the stakeholders and they came up with a number of recommendations/interventions to address the shortcomings in weather forecast approaches in future for ASAL parts of Baringo County (Figure 7.7).

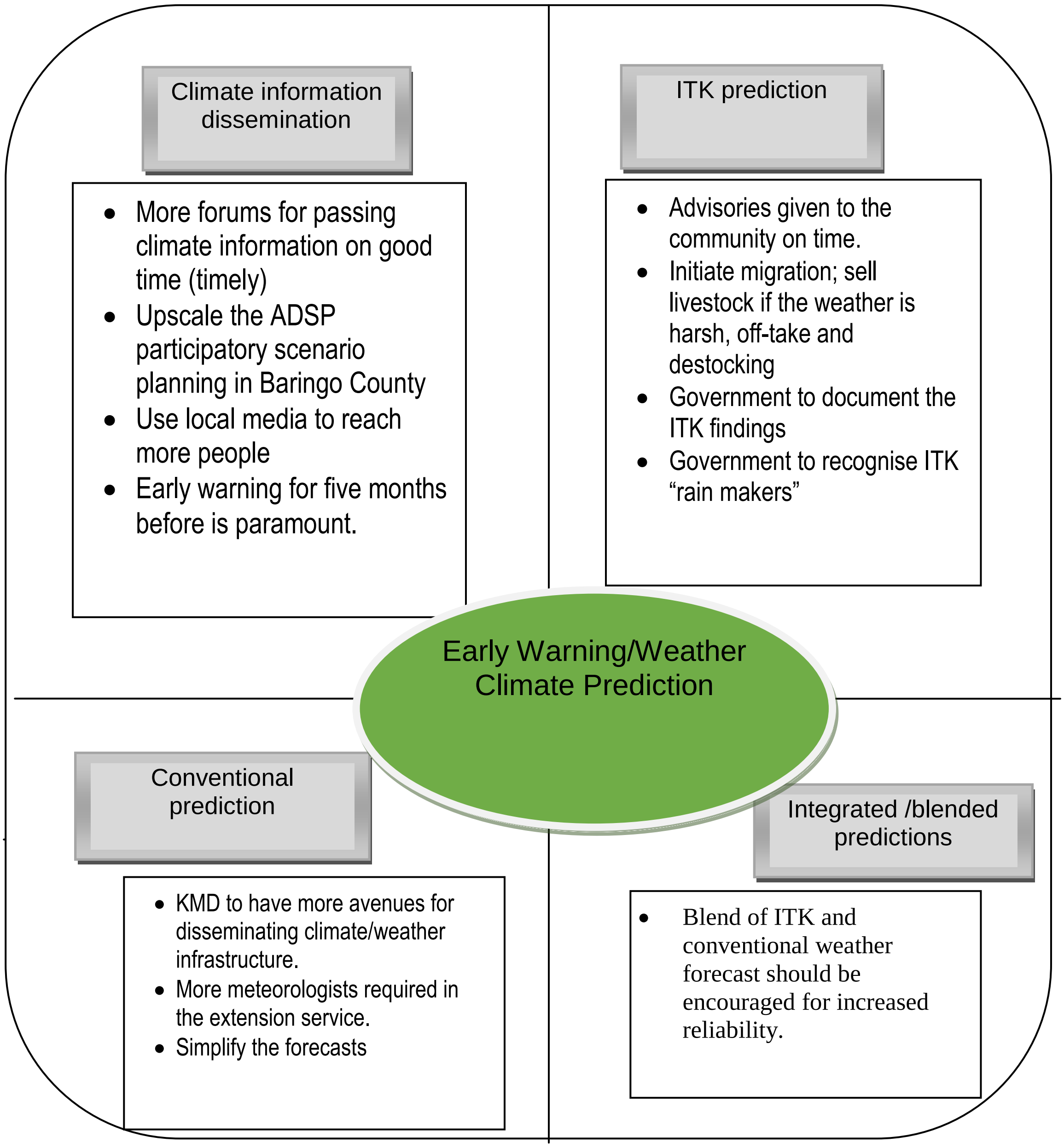


Figure 7.7: Recommended interventions for early warning in the ASALs Baringo County

They discussed the early warning system in four dimensions: Climate information dissemination, ITK, conventional and integrated/ blended prediction (Fig. 77). A stakeholder discussant said, "*early warning system from NDMA provides weather predictions one month before but the pastoralists cultural attachment to the livestock contributes to a great loss of their livestock during drought period*". This was supported by another discussant who said "*It is either the cow to die or I die*", this is a common saying among the Masaai pastoralists in Kenya, when urged to sell their livestock due to drought. A key informant stated that, "*50 percent of the livestock farmers rely on ITK weather forecast in Baringo County*". Further, the KI argued that the ITK is easily accessible to the livestock since it is localized. "*Getting climate/weather forecast from KMD is not easy as from ITK, since we leave together with the "rainmakers",* a stakeholder said in the stakeholders' engagement forum. "*The way the weather forecast is disseminated is critical as it determines the rate of uptake by the livestock farmers*", another discussant said in an FGD.

A key informant from ASDSP reported that Baringo County has diverse communities, who include the Tugen who are made of Alolu and Dolosi, Pokot and Ejamus, who are well known for weather prediction. She argued that the latter two are very close in precision and almost certain of the prediction. "*We as the ASDSP normally combine their early warning indicators that are different but they converge at a point. Also, we bring the KMD for conventional weather forecast and listen to the both ITK and KMD then we agree whether the predictions will be above normal, normal or below normal. We then come up with advisories based on different sectors such as agriculture, water and health*'' An extraction of the advisory document is presented in this thesis (see plate 5.1 and appendix 13). It is the communities who come up and agree with their own observation. Based on this agreement, "*ITK weather forecast is becoming very good among the pastoral communities in Baringo County and the old long experienced weather forecasters (community "rain maker" who have been serving their communities for many years and have grown old) should mentor young ITK*", a discussant in an FGD said.

7.3.4 Policies and actions

The following are the stakeholders recommended areas that require appropriate policy and action to enhance efficiency and effectiveness of livestock production and marketing in ASAL parts of Baringo County in the face of climate change and variability (Figure 7.8).

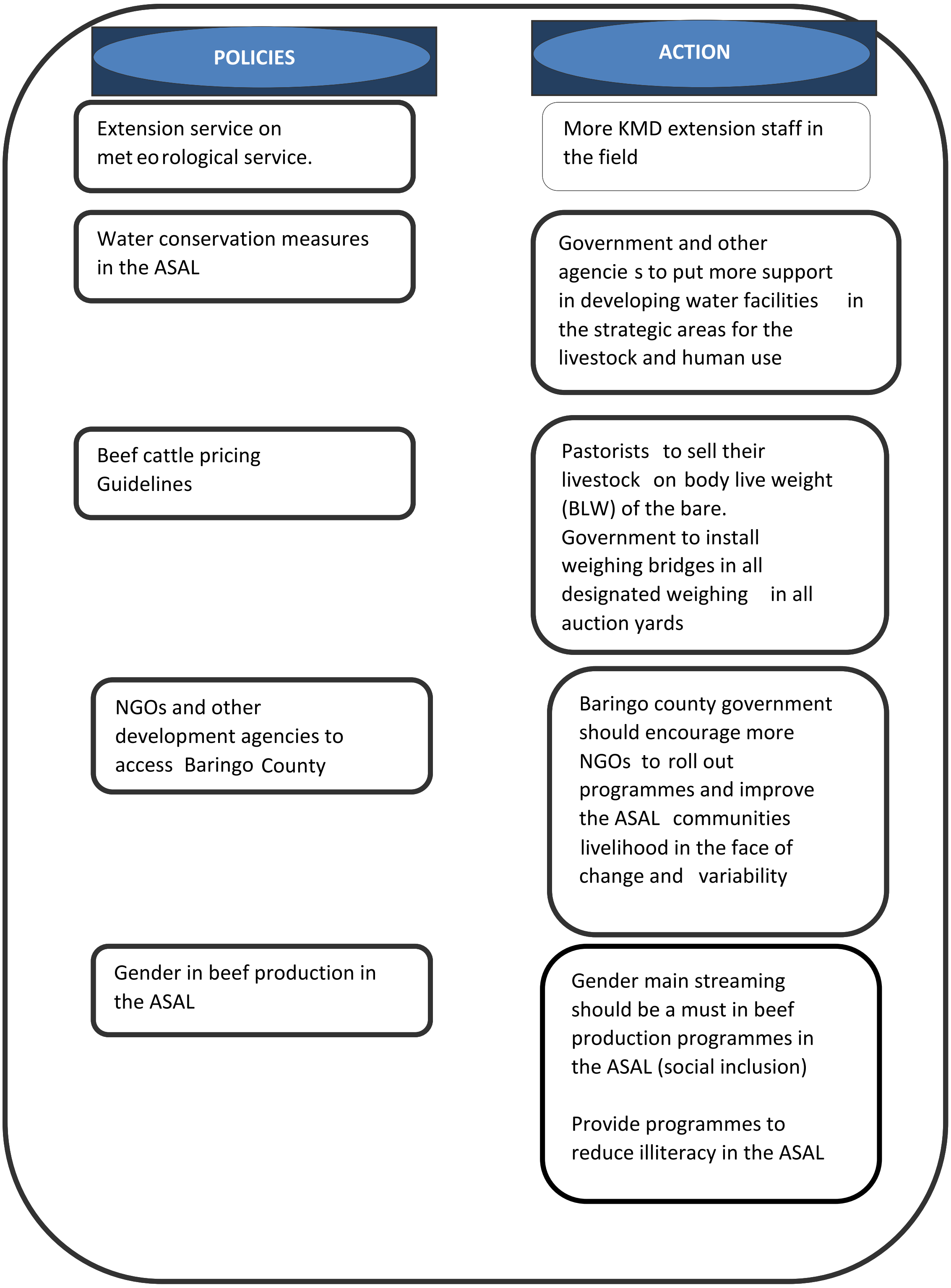


Figure 7.8: Stakeholders recommended appropriate policy and actions.

As shown in Figure 7.7 the stakeholders consultative forum found that there were no adequate meteorological extension services. They recommended more KMD extension staff to be posted to Baringo County. The policy on water conservation in the ASAL was revisited. It was recommended that, government and other agencies to support the development of more water facilities in the strategic areas for human and livestock.

7.3.5 Other recommendations

The stakeholders' engagement discussed other areas that were not in the above-mentioned aspects and recommended that research institutions should come up with climate smart technologies to address the adverse effects of climate change and variability. Also, emphasis was to be put on more research on the emerging diseases associated with climate change. They further recommended that the Government supports rehabilitation of the environment which has been devastated by climate change and variability in Baringo County.

Table 7.1 revealed that majority of the communities living in the ASAL parts of Baringo County control breeding of their livestock as a means of averting adverse impacts of seasonal climate variability. Although there is climate change and variability, the farmers in the ASAL had been relying on Indigenous Traditional Knowledge (ITK) for seasonal weather predictions. "*They control the breeding of their livestock if the ITK forecasters forecast a dry season ahead and if vice versa, they allow the breeding of the livestock*," a discussant in FDG reported. However, due to the complexity of climate change, the ASAL communities are unable to rely on the ITK for the weather forecast, said one of the FGD participants. According to Assan (2014) one of the feasible options of adapting to climate change effects on livestock production is promoting local indigenous livestock species; indigenous livestock species represent a genetic resource which is resilient to climate variability and should not only be conserved for future use but also utilized as a potential tool to mitigate against climate change effects.

It was reported in chapter five that majority of the respondents reported to have not been aware of the blend/mixture of Indigenous and Conventional Forecasting Techniques. Although some reported to have been using both, majority were not aware of it. The awareness creation for the blend/mixture of indigenous and conventional forecasting techniques to the farmers should be enhanced through the already existing PSP forums by the ASDP. This should be done jointly with the Meteorological Department in the County.

Table 7.2 revealed majority of livestock farmers in the ASAL parts of Baringo County apply the weather forecast information on cessation of rainfall to manage their livestock production and marketing activities. Among the several climatic events under review, the prediction of when the rainfall will cease was the most applicable among the respondents. However, based on the findings it is explicitly clear that weather/climate forecast information is applicable to the livestock keepers in the ASALs, and farmers knowing the cessation of the rainfall in advance is an important aspect in managing their livestock. In general terms, the findings in this study concur with Frisvold et al. (2013) who reported that the intensity of weather data use was greater among producers with diversified agricultural production. Diversified producers were more likely to use data for timing of planting, cultivation, and harvest. Weather data use was lower among producers with greater reliance on off-farm income.

The study finding shows that majority of the livestock farmers in the ASAL parts of Baringo County stated that their preferred source of weather and climate information in the study area is conventional (scientific) and is sourced from the Kenya Meteorological Services and other weather/climate information agencies, where they disseminate the information through radio. This finding corroborates Rajesh (2016) that radio is the most common medium through which pastoralists receive external climate forecasts. Onyango et al. (2012), also revealed that majority of farmers receive weather and climate information mainly through radios and also local administration, but found that only a few find the information useful in their operational decisions.

Table 7.3 shows that the majority of the livestock farmers in the ASALs parts of Baringo County reported fluctuations in livestock production especially during prolonged dry periods. Further, it was coincidentally reported by the majority that the context of climate variability creates a demand for livestock value chain products such as meat and milk, especially during times of prolonged droughts. They identified this as an opportunity in livestock production and marketing in the context of climate change and variability.

Figure 7.3 revealed that the majority of the livestock farmers in the ASAL parts of Baringo County are willing to pay for the weather/climatic information which they can use in planning for their livestock production and marketing. This implies that that the farmers know the importance of quality weather information/climatic information. For example, in the Focus Group Discussion it came out explicitly that reliable seasonal weather prediction can assist the farmers to plan for their livestock in the aspects of the pasture and water. Also, farmers can organize their livestock for the appropriate season to market their stock. Table 7.4 shows that majority of the livestock farmers in the ASAL parts of Baringo County had the opinion that government involvement, for both in ITK and conventional weather forecasts and farmers' access to information, respectively, will improve the reliability of ITK and conventional (scientific) weather forecasts.

Wato (2016**)** noted that among the conspicuous threats of climate change and variability to the ASAL communities are; decline in crop production, livestock deaths due to droughts, malnutrition, resource-based conflicts, and migration. From the FGDs held, it was revealed that there had been frequent prolonged droughts with devastating impacts on livestock, and the farmers could lose a lot of livestock through death. One of the participant said, "*the seasonal migrations to evade drought do trigger cattle rustling and therefore the Peace and Reconciliation Committee and Administration Police need to put measures in place to minimize such incidences which are already being experienced in some areas*."

7.4 Conclusion

Based on the findings, the stakeholders' engagement identified key problems associated with inefficiency and ineffectiveness of livestock production and marketing in the face of climate change and variability in the ASAL parts of Baringo County at the time of this study as: ITK unreliability in weather prediction, conventional weather forecast information not understood by the farmers, and inaccessible and overreliance on old livestock breeds. The recommendations /interventions were community based on livestock production and marketing, early warning/weather forecasts, policies and others.

The study revealed that the ASAL communities in Baringo County are using local livestock breeding programmes as an adaptation strategy to climate change and variability. They control the livestock breeding based on the ITK weather forecast advisory services from the rainmaker.

If a long rain season is predicted, the farmers go ahead allowing the breeding of their livestock ahead of the predicted rainfall so that their livestock calve down when there will be plenty of pasture and water. However, majority of the respondents claim to have been using both ITK and conventional weather forecasts, although most were not aware of the existence of the blend/mixture of the two-weather forecast in Baringo County. Based on these findings, the researcher recommends vibrancy in the existing PSP forums by ASDSP to promote and create more awareness of the importance of the blend/mixture of the two weather forecasts in enhancing livestock production and marketing in the face of climate change in Baringo County. Further, the study showed that majority of the ASAL communities in the study area were interested in knowing when the rainfall season is ceasing for them to plan on how they will manage their livestock when the dry spell comes in within the year. They access most of this weather information through radio and administration offices within the study area.

On the importance of the weather information to the respondents' livelihood, the majority expressed willingness to pay for the information. They argued that the information will help them to plan for their livestock both for the production and marketing activities. For the reliability of the two sources of weather forecasts, majority of the respondents suggested that that the government should control the quality and the interpretation of the information to the ASAL communities in Baringo County. However, there was a great concern by the respondents about the manner in which the information is disseminated to the them. Therefore, for the weather forecast to be more effective and efficient to the respondents' usage in livestock production and marketing, the current dissemination mode needs to be reviewed.

CHAPTER EIGHT: SYTHESIS AND DISCUSSION

8.1 Introduction

This chapter describes and discusses the combination of the key findings from chapter four to seven of the thesis. Further, in the presentation, the chapter focuses on the overall objective and the elements of the conceptual framework. It addresses them in the following aspects; seasonal climate variability, ITK weather forecast technique, conventional weather forecast technique, impacts of seasonal climate variability on livestock production, impacts of seasonal climate variability on livestock marketing, impacts of weather forecast on livestock production, impacts of weather forecast on livestock marketing, transdisplinary approach, integrated climate/weather forecast adaptation strategy in Baringo County.

8.2 Seasonal climate variability

This study found that Baringo County has been experiencing an oscillating trend in rainfall with a significant peak observed in 1977. Other observable peaks are those of 1988-89 and 1997-98 from 1971-2007. These are the four major peaks with the highest amounts of rainfall over the last four decades. It is worth noting that the area has been receiving heavy rainfall in every ten years over the 1971-2010 period. This study finding agrees with Lelenguyah (2013) and Ochieng et al. (2017) who reported a declining long-term seasonal rainfall trend in the drylands of Baringo County. Further, Wakachala et al. (2015) reported a decreasing trend in annual rainfall during March-April-May season and high variability within seasons in the Great Rift Valley of Kenya. Although the study area has been experiencing an oscillating trend in rainfall, it is important to note that the amount of annual average rainfall has been decreasing with time (Figure 3-5). It is perhaps associated with the aspect of climate change and variability. Further, the study results corroborate Omoyo et al. (2015) where rainfall trend analysis for 1994–2008 revealed that four of the six weather stations in Machakos County, Kenya, were declining up to 3 mm pa. A similar study by Mwaura et al. (2017) reported that rainfall in semi-arid Ijara in Garissa, Kenya, has increasingly become uncertain and the trend analyzed using KMD data (40 years) period indicates a definite decline. Also, Recha et al. (2017) who analyzed precipitation data for 10 years in semi-arid Tharaka District, Kenya, reported similar results that showed a declining trend between the 1970s and mid-1980s.

Based on the general trends of the rainfall in all the weather stations reviewed, it was observed that the rainfall has been decreasing from year to year. Further, the summary of mean annual maximum and minimum annual rainfall and coefficient of variability for the six weather stations (1974-2003) shows there is variability of rainfall across the stations and from year to year, although it highest at Lake Bogoria, followed by Snake Farm and Perkerra. The trends in all the stations were not statistically significant ($p>0.05$).

8.3 ITK weather forecast technique

Although during the time of this study majority reported to be using information from both weather forecast (conventional and ITK), a significant proportion of the pastoralists and agro-pastoralists had been relying on the ITK weather forecast in making decisions regarding their livestock production and marketing. This was further enhanced by an FGD discussant who said, "*We have lived long in these hard conditions of weather changes and we have been entirely depending on our "rainmakers", but of late we are losing may livestock especially in the prolonged dry spell*". This supports Onyango (2018) who asserted that local solutions can help beat climate change. A veteran farmer has proposed where a crop and livestock farmer and an agricultural solutions expert in Kajiado County says African Indigenous Knowledge Systems (IKS) are crucial to addressing effects of climate change in Kenya. "*From October this year, I have lost 130 heads of cattle. This shows how urgently Government should engage us to get our views on how to incorporate our indigenous System in improving agriculture*," he says.
https://www.standardmedia.co.ke/article/2001267732/how-african-indigenous-knowledge-in-weather-forecasts-agriculture-can-enhance-food-production.

8.4 Conventional weather forecast technique

Most of the pastoralists and agro-pastoralists interviewed pointed out that the conventional weather forecast approach is reliable in predicting long-rains seasons, short-rains seasons, expected rainfall onset and cessation, rainfall intensity, seasonal rain distribution as well as temperatures. It can also be seen that the conventional weather forecast approach is also a reliable predictor of extreme climatic conditions in the study area. However, the study established from majority of the respondents that the conventional predictions are not reliable for some climatic conditions namely, La Niña, landslide, and drought.

The study found that, most of the pastoralists and agro-pastoralists have not been aware of the blend/mixture of indigenous and conventional forecasting techniques. However, this is contradicted by the finding in the same study where the majority reported to have been using both conventional and ITK. It is most likely that they got these two different weather forecasts separately unlike in the case of the integrated weather forecast from the ASDSP programme. Therefore, awareness creation on the blend/mixture weather forecast technique is required to enhance this new initiative (ASDP, 2015). The finding agrees with Netshiukhwi et al. (2013) who noted that farmers relied almost fully on their experience and traditional knowledge for farming decision making. This finding is further supported by the stakeholders' engagement forum where they recommended up scaling of the integrated seasonal climate forecast in the study area. Also, an FGD discussant said that "*we pastoralists in this area we rely upon ITK weather forecast where animal intestines can predict the weather with the interpretation of our rainmakers*". On the same notion, a KI reported that the farmers in the study area tend to believe more in ITK than conventional forecasts.

8.5 Impacts of seasonal climate variability on livestock production

Figure 4.16 revealed that there was impact of seasonal climate variability (mean areal precipitation) on the population of cattle, goats and sheep in Mogotio and Baringo South sub-counties for the period 1999-2003. It implies that there was a positive relationship between population of goats and sheep versus mean areal precipitation. The latter yielded a very strong relationship while the former was moderate. However, it is only cattle that yielded a negative and moderate relationship. This means that as the amount rainfall increases the population of goats and sheep increases as well. This is most likely related to more lambing and kidding during rainy seasons since there is adequate pasture and water. However, the small ruminants' gestation period is far much shorter than that of cattle and more "crop" is expected within a short period. At the same time, cattle are more prone to climate change related emerging diseases than sheep and goats. Rift Valley Fever (RVF) is an epidemic that sometimes occurs at the time of floods and East Coast Fever (ECF) in dry seasons. Therefore, the mortality rate is high when there is high rainfall, especially so in the ASAL.

Figure 4.8 shows the impact of seasonal climate variability (mean areal precipitation) on the developed hectares of Napier, improved pasture and natural pasture and Fodder trees for livestock feed for the period 1999-2003 under review. The findings showed that there was a positive relationship between Napier, natural pasture and Fodder trees versus mean areal precipitation, although the fodder trees yielded the strongest positive relationship. However, the improved pasture yielded a negative and very weak relationship. This means that as the amount rainfall increases, the developed number of hectares of Napier, improved pasture and natural pasture and Fodder trees increase as well. It is most likely that less developed number of hectares of the same fodders and pasture has been recorded due to the frequent and prolonged dry spells being experienced in Baringo County in the face of climate change and variability and this situation adversely affect the livelihood of pastoralists who entirely relies on livestock.

8.6 Impacts of seasonal climate variability on livestock marketing

This study revealed that the seasonal climate variability had an impact on livestock marketing on the aspect of unit average prices for cattle, goat and sheep for period 1999-2003 under review in the study area**.** The highest prices sold per unit cattle, goat and sheep were Ksh. 11,870, 2,100 and 1,280, equivalent to $115.1, 20.4, 12.4 using conversion rate of I US dollar equals to Ksh.103.12, respectively. The lowest prices sold per unit cattle, goat and sheep were Ksh. 8,250, 1,500 and 850 ($80, 14.5, 8.24), respectively. Further, the impact/association of seasonal climate variability to unit average prices for cattle, goat and sheep for period 1998-2003 under review showed a negative relationship between unit price of cattle and goats sold for slaughter and mean areal precipitation. However, this relationship varied across the three species of livestock where cattle, goat and sheep yielded very strong, strong and moderate relationship, respectively. The study also demonstrated that there was very strong negative relationship between mean areal precipitation and quantity of cattle sold for slaughter, while for the goat it yielded weak relationship for period 1999-2003 under review in Baringo County. There was no relationship between the seasonal mean areal precipitation and the quantity of sheep sold for slaughter.

8.7 Impacts of weather forecast on livestock production

The study showed that majority of the livestock farmers in the ASAL parts of Baringo County argued that the indigenous knowledge they practice in weather forecasting has an impact on the calving rate, calving interval, fertility growth rate as well as the milk production of their livestock (Table 6.1). It came out clearly in the FGD that the indicators for traditional knowledge are embraced in broad terms, relying on the stories and indications from observations and years of experience of their use by the farmers in managing their livestock production. Netshiukhwi et al.

(2013) argued that engagement with the natural environment are skills not well understood by most scientists, but useful to the farmers. They range from the constellation of stars, animal behavior, cloud cover and type, blossoming of certain indigenous trees, appearance and disappearance of reptiles, to migration of bird species and many others. It is suggested that some short-term traditional forecasts/predictions may be successfully merged with science-based climate predictions. The study further revealed that majority of the livestock farmers in the ASAL parts of Baringo County expressed that both conventional and ITK weather forecast had impact on the breeding, productivity, pasture management, destocking, off-take, water management, disaster risk management, livestock herd size, livestock herd composition, new breeds, fodder storage, livestock de-worming and disease control.

8.8 Impacts of weather forecast on livestock marketing

The study found that majority of the pastoralists and agro-pastoralists interviewed perceived that the indigenous weather forecasts have negative impacts on livestock marketing attributes that include purchasing price, purchase of livestock, livestock sales, sales in auction yard, number of livestock sold, and sales outsides the sub-county. Further, the study, through the opinions of respondents, established that conventional weather forecasts have impacts on livestock marketing attributes as pointed out by the majority, sales outsides the sub-county, sales in auction yard, sales, number of livestock sold, purchasing price as well as the purchase of livestock.

Based on the triangulation of the study finds, the majority of the interviewed key informants reported that the level of the farmer preparedness, before weather/climate extreme event strike, has an impact on the performance of livestock productivity and marketing. This was further supported by findings derived from the focus group discussions on market response to seasonal weather forecast based livestock marketing plan. According to the livestock farmer, traders, extension agents abattoirs owners and managers as key informants of this study, Mogotio and Baringo south sub-counties in Baringo County experience three seasons: long rainfall season (March, April and May), short rainfall season (October November and December) and dry season (January-March).

During the long rainfall season (MAM) in Baringo County there is plenty of food and as such the households are food secure. The demand for money is low since there is less or nothing to purchase as food with money. The livestock farmers in the auction sales yard experience livestock price increase, little supply of livestock to sell, and high demand for young stock. While farmers buy young stock for breeding and fattening from the livestock traders, farmers are not willing to sell their livestock.

The short rainfall season is experienced in October to December (OND). During this period the prices for livestock are high and as such it is a good time for the farmers to sell their livestock. It is termed as the “field day for farmers”. The demand for livestock is high in the sales auction yards. During this season livestock farmer maximize the sales, categorized as the “best” sales period. The festive season in the month of December, which coincides with the above-mentioned period, contributes, greatly in the creation of the high demand for livestock species.

High concentration of cattle, sheep and goats in the livestock market (auction sales yard) is observed in the dry seasons. This reflects that supply of the cattle, sheep and goats is high and consequently the prices are low. The reasons were; the dry season usually commences in January when schools open and the parents who are the livestock farmers are to pay school fees, and the local consumers have no purchasing power to buy meat due to the live pressure. Therefore, the whole period January up to March is the “field days” of the livestock brokers in the market.

8.9 Transdisplinary approach

The application of the transdisplinary research approach in the study was paramount. This approach created a holistic understanding of the subject of inquiry. It encompassed the engagement of the stakeholders’ in a non-academic environment. In this context, knowledge relating to impacts of seasonal climate variability and weather forecasts on livestock production and marketing was sourced from pastoralists, agro-pastoralists, local ITK experts, meteorologists and other stakeholders indiscriminately. They came up with appropriate recommendation/ interventions to enhance efficiency and effectiveness of livestock production and marketing. These adaptation strategies were incorporated in the development of an Adaptation to Climate Change Framework for Baringo, Kenya (Figures 7.1 and 7.5-7.9).

8.10 Integrated climate/weather forecast adaptation strategy

Based on findings in Table 5.2, majority of the pastoralists and agro-pastoralists are not aware of the blend/mixture of indigenous and conventional forecasting techniques. This is most likely because the initiative is new in the study area. ASDSP (2015) noted that the purpose of the Participatory Scenario Planning (PSP) is to endorse the combination of ITK and conventional (scientific) weather forecasting in climate risk management in Baringo sub-counties. The PSP forecast has an enhanced intellect of ownership by farmers/pastoralists and decision makers, hence contributing to the overwhelming uptake of the disseminated hybrid/integrated weather forecast. The findings support Glatnz (2003, 2005) and Goddard et al. (2010) arguments that climate scientists are increasingly under pressure to go beyond their disciplinary confines and engage in a process of joint, continued and participatory learning with users of the information and to encourage effective outreach programmes for the information to realise its full potential.

However, although several adaptation strategies came up from the study, the key output of the study finding was the blended/mixture climate/weather forecast. This is where both the ITK and conventional forecasters' opinions are brought together and come up with a comprehensive climate/weather forecast which is a more reliable weather forecast. Kolawole et al. (2014) contended that indigenous traditional knowledge on weather scenarios, enhanced by further research and scientific knowledge need to be integrated for better decision making. Further, Kolawole et al. (2014) pointed out that farmers and scientists need to agree on local indicators (weather predictors), which in their present forms, vary in interpretations from one locality to the other. Integration of these two knowledge systems may also correct the seemingly wrong perceptions of some stakeholders (e.g. policy-makers, politicians, academics/scientists, etc.) that local knowledge is not well positioned to handle the complex contemporary problems of an ever-changing environment.

Also, Chang'a et al. (2010) argued that amalgamation of indigenous knowledge with conventional weather forecasting system is endorsed as one of the strategies that could help to improve the accuracy of seasonal rainfall forecasts under a changing climate and variability. During the time of this study, this strategy was being practiced under the coordination of the Agricultural Sector Development Support Programme, although in small scale. This involved generation of seasonal rainfall advisories for Baringo and Mogotio sub-counties (ASDSP 2015).

8.11 Conclusion

Based on the study findings, Baringo County has been experiencing annual rainfall variation from year to year for the period 1974-2003. The variability has not been consistent in all the areas covered by the weather stations under review. Area covered by Lake Bogoria, Perkerra and Snake Farm had a higher variation than Chemususu and Kimose areas. It is perhaps because the formers stations are in the lowlands (Marigat/Baringo south and Mogotio Sub-counties) while the latter are in the highlands. Also, it was noted that, there has a general decrease in annual rainfall and an increase in air temperature.

There has been positive impact of seasonal climate variability (rainfall) on population of goats and sheep. As the rainfall increases the population of goats and sheep increases as well, while cattle decrease. This is most likely related to more lambing and kidding during rainy seasons since there is adequate pasture and water. However, there was negative impact on cattle population. The cattle are more vulnerable to epidemics diseases such as Rift Valley Fever during the rain seasons especially so when there are floods. On livestock marketing, this study revealed that the seasonal climate variability (rainfall) had an impact on livestock marketing on the aspect of unit average prices for cattle, goat and sheep

A significant proportion of the respondents claimed to have been using forecasts from both the conventional and ITK in making livestock production and marketing decisions. On reliability status, majority of the respondents perceived that blended forecast is most reliable. However, the most popular forecast is ITK. The blended weather forecast is where the forecast is a product of an organized forum of both conventional and ITK that comes up with one forecast referred to as “blended or mixture or integrated forecast”.

Majority of the respondents expressed the view that the ITK weather forecast has a positive impact on calving rates, calving interval, fertility, growth rate, and milk. A significant portion of the respondents interviewed perceived that conventional weather forecast practiced has a positive impact on fertility, growth and milk production of their livestock. The study findings showed that in milk, growth rate, fertility, calving rate and calving interval were statistically significant. These findings confirm that blended ITK and conventional is the best forecast that impacts on the livestock production performance. On the livestock marketing, the findings revealed that “blended” weather forecast had a significant relationship for all the market attributes under review except for purchasing price.

CHAPTER NINE: GENERAL CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

The general conclusion of this study is that Baringo County, over the period 1974-2003, has experienced a large spatial and temporal variation in rainfall, coupled with a general decreasing trend. The amount of rainfall received in the long and short rain seasons is continuously decreasing while the dry spell is increasing. Based on the above finding, the study has validated the pastoralists' claim that the rainfall pattern has changed and that they are sometimes unable to predict the seasons. They are trying to adapt to these changes by embracing seasonal weather forecast based planning, through Seasonal Rainfall Advisories (SRA) for Baringo Sub-Counties (ASDSP, 2015). This identified situation poses reality of climate change and variability in the study area. The rainfall variation had an impact on the livestock production, among the three species of livestock under review; the sheep population demonstrated a very strong positive association with the amount of rainfall received within the period under review. For the number of hectares of fodder and pasture developed, the result shows that fodder trees yielded the strongest positive association with the rainfall variation. On the impact of the rainfall variation on the livestock marketing, the price for unit cattle yielded the strongest negative association, while the number of cattle for sold for slaughter demonstrated a strong negative association. Further, the study revealed that preparedness before weather extreme event strikes such as drought or dry spell has a positive impact on the performance of livestock marketing.

The ITK weather forecast has an impact on the livestock production performance in the aspect of calving rate, calving interval, fertility, and growth rate and milk production. For livestock marketing, both the ITK and the conventional had an impact on the purchasing price, purchase of livestock, livestock sales volumes, sales in the auction yard, number of livestock sold, and sale outside the sub-county. Further, the study showed that there is a significant difference in the impacts of ITK and conventional weather forecast on livestock production and marketing decisions in the study area.

It also revealed that Baringo County experiences three rainfall seasons. These are the short rains season, long rains season, and dry season which cover the biggest portion of the year. In the long rains season, high prices for livestock are offered in reciprocate to high demand for young stock.

During the short rains, the prices are high and the period is referred to as a “field day for farmers”. Eventually during the dry season, the prices of livestock are low due to high supply of livestock in the sales auction yard.

The stakeholders’ engagement identified key problems associated with inefficiency and ineffectiveness of livestock production and marketing in the face of climate change and variability in the ASAL parts of Baringo County at the time of this study as: ITK unreliability in weather prediction, conventional weather forecast information not understood by the farmers and inaccessible and overreliance on unimproved local indigenous livestock breeds. Also they proposed solutions as: avoid over reliance on natural pasture, keep drought resistant livestock breeds, change from nomadic and embrace holistic approach, develop more water pans and dams, introduce a vibrant extension service on climate smart agriculture, more slaughter houses and secured auction yards, formation of more organized marketing groups, awareness creation on weather patterns (effective early warning system) build capacity of pastoralists on seasonal climate /weather forecast based management, and mainstream gender mainstreaming in beef production.

9.2 Recommendations

This study has shown that the impacts of seasonal climate variability and weather forecasts on livestock production and marketing have been worsened by the pastoralist and agro-pastoralists practicing livestock production and marketing without reliable and correct climate/weather forecast information in the face of climate change and variability. Based on the results from this study, the following recommendations were suggested:

1) **Upscale the already existing seasonal rainfall advisories by ADSP for Baringo sub-counties based on participatory scenario planning (PSP) and integration of knowledge of various sources:**

Climate change is a complex, outstanding issue in the society. It requires an integration of different sources of knowledge where the transdisplinary approach is embraced in a non-academic environment. The community itself should be encouraged to participate in addressing the climate change and variability problems for them to own the solutions. The forum should bring on board participants from all stakeholders and those with Indigenous Technical Knowledge and meteorologists from KMD endeavour to give accurate and timely information to the farmers.

2) **Establish model farms each in every sub-county which is practicing seasonal weather forecast based management in livestock production and marketing:**

The model farms should be designed in way that it provides a training platform for the pastoralists and agro-pastoralists. It should exhibit livestock production systems and marketing models that are appropriate for the ASAL in the face of climate change and variability. The management of these model farms should be propelled by seasonal weather forecast based principles where livestock farmers would be coming to learn and go back to their areas to practice.

3) **Adaptation strategies to climate change and variability should be location specific**:

The Baringo County has spatial and temporal variation of climate variability depending on the location. Based on this characteristic, the adaptation strategies should be specific, the lowlands areas such Baringo South and part of Mogotio sub-counties are drier than the high altitudes areas such as Kabarnet. Therefore, this study recommends that all generated and developed interventions to address the impacts of climate change and variability should be specific but not a blanket prescription. For instance, in the lowland more water pans and dams especially in Marigat/Baringo south sub-county should be developed as an adaptation strategy since pastoralists and agro-pastoralists will have access to water for irrigating pasture/fodder and food crops as well for livestock and human beings. This above-mention strategy is specific and cannot apply to the highlands like Kabarnet environs where the varieties of crops and livestock breeds recommended are different.

4) General improvement of the livestock production and marketing infrastructure

Most of the ASAL in Kenya lack adequate livestock production and marketing infrastructure, Baringo County is not exceptional. According to the stakeholders' engagement, it came out clearly that the County has poor road network, lacks secure sales yards, slaughter facilities/only slaughter slabs that do not meet standards for export, and lack of adequate water storage and pasture. Therefore, based on the findings of this study, the researcher recommends diversified ways of water harvesting e.g. water pans and earth dams for livestock, human consumption and irrigation as well as general improvement of the road networks in the ASAL parts of Baringo County.

9.3 Recommendations for future research

It is of importance to have future research in order to have a more comprehensive understanding of the impacts of seasonal climate variability and seasonal weather forecast on the livestock production and marketing in Baringo County. This study recommends the following areas for future research:

(1) The impact of seasonal weather forecast based management on livestock and marketing among the pastoralists and agro-pastoralists in Baringo County.

(2) Evaluation of the packaging and dissemination of climate information as an early warning indicator to livestock producers and marketers in Baringo County

(3) Assessment of the adaptive capacity of the pastoralist and agro-pastoralist to climate change and variability in Baringo County.

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Appendices

Appendix 1a: Household Questionnaire

Questionnaire

Date of interview..
Interviewer..
DETAILS OF RESPONDENT
Name.. Sub-county...
Ward...
Location..
A).Household Socio-economic Characteristics

1. What is the relationship of the respondent to household head? (*Tick what apply***)**
   00=Head
   01=Spouse
   02=Parent
   03=Child
   04=Grandchild
   05=Nephew/Niece
   06=Son/Daughter-in-law
   07=Brother/Sister
   08=Other related (specify) ________________________
   *09=Other unrelated (specify)*_______________________

2. Gender of the respondent *01=Male* *02=Female*

3. Size of household, by age (*Insert what apply*)

Range of age of household members by years	<5	5-25	25-45	45-60	60-75
Size of household (Number)					

4. Highest level of education of household head
   00= no education; 01= Primary; 02 = Secondary; 03=Post secondary

5. Highest level of education of the respondent interviewed
   00= no education; 01= Primary; 02 = Secondary; 03=Post secondary
6. Household type
   01=Male headed, with a wife or wives,
   02=Male headed, divorced, single or widowed,
   03=Female headed, divorced, single or widowed,
   04=Female headed, husband away, husband makes most household/agricultural decisions,
   05=Female headed, husband away, wife makes most household/agricultural decisions,
   06=Child headed (age 16 or under)/Orphan

7. Primary occupation or source of livelihood
   01=Keeping livestock alone 02=Keeping livestock and farming 03=Fishing
   04=Business(trading)

8. How many years spent in this (Q.7) activity?
   00 = <5 years; 01 = 5-10 years; 02 = >10 years

9. Which of the following livestock species does your household own currently? (*01=Yes, 00=No) if yes indicate the number of each*

Livestock			
Cattle	[__ __]	[-- -- -]
Goats	[__ __]	[-----------]
Sheep	[__ __]	[………….]
Poultry	[__ __]	[………….]
Other ______________________		

B) CLIMATE INFORMATION

10. Do you or your family receive weather and climate information at present?
    00=Yes *01=No*

11. In the table below, indicate the different type(s) and source(s) of weather and climate information you or your family receives:

	Did you receive any information ?	**From whom or how did you receive the information ?**	**Who received the information in the household?**	**Did it include advice on how to use the information in your livestock Production and marketing?**	**How useful was this information to you/your family?**
Type of information	*01=Yes, 00=No*	*(List up to three* ***See codes at the bottom of this table***	*01=Men, 02=Women, 03=Both*	*01=Yes, 00=No*	*02= Very, 01=Somewhat* *00=Not at all*
Forecast of the weather for today, 24 hours and/or next 2-3 days	[__ __]	[__ __] [__ __] [__ __]	[__ __]	[__ __]	[__ __]
Forecast of the weather for the following 2-3 months	[__ __]	[__ __] [__ __] [__ __]	[__ __]	[__ __]	[__ __]
Forecast of the start of the rains	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]

	Did you receive any information ?	From whom or how did you receive the information ?	Who received the information in the household?	Did it include advice on how to use the information in your livestock Production and marketing?	How useful was this information to you/your family?
Type of information	*01=Yes, 00=No*	*(List up to three* ***See codes at the bottom of this table***	*01=Men, 02=Women, 03=Both*	*01=Yes, 00=No*	*02= Very, 01=Somewhat* *00=Not at all*
		[__ __] [__ __]			
Forecast of cessation of rains	[__ __]	[__ __] [__ __] [__ __]	[__ __]	[__ __]	[__ __]
Forecast of drought, flood, frost, cyclone, tidal surge or other extreme event	[__ __]	[__ __] [__ __] [__ __]	[__ __]	[__ __]	[__ __]
Forecast of pest or disease outbreak	[__ __]	[__ __] [__ __] [__ __]	[__ __]	[__ __]	[__ __]

Codes – Sources of information: *00=National meteorological services; 01=Television; 02=Newspaper; 03=Radio; 04=Drought monitoring center; 05=Government extension officers; 06=Private climate services providers; 07=Internet/Website; 08=E-Mail; 09=SMS; 10=Phone call; 11=Meetings; 12=Traditional methods (specify); 13=Other (specify).*

12. If your response to question 10 above was **Yes**, evaluate the quality of weather and climate information you received with regard to supporting the following decisions or activities:

Decision/ Activity	**Quality of Information**			**How useful was this information to you and your family**
	Excellent	Average	Poor	02=Very 01=Somewhat 00=Not at all

Livestock breeding plan				
Livestock productivity				
Livestock marketing time				
Number of livestock to sell				
Determining the price of livestock				
Pasture management				
Destocking and off-take				
Water management				
Disaster risk management				
Livestock herd size				
Livestock herd composition				
New livestock breed				
Fodder storage				
Livestock de-worming				
Control of livestock diseases				

13. Have you experienced any of the following in the past ten years? (Tick all that apply)
    a) *Heavy rain and hail* [ ]
    b) *Problems with frost* [ ]
    c) *Seasonal floods* [ ]
    d) *Drought* [ ]
    e) *Landslides* [ ]
    f) *Livestock diseases/outbreaks* [ ]
    g) *New invasive plants (weeds)* [ ]
14. If yes for any of the above, did you have prior- information before it happened?
    00=No *01=Yes*

15. If you had prior- information, what was the source of the information?................ **Codes:** 00=*Kenya Meteorological Services, 01=traditional "rain makers", 03=Others (specify)*

16. For the question 15, through which means did you receive?...

Codes– Sources of information: *00=National meteorological services; 01=Television; 02=*newspaper; 03=radio; 04= *National Drought Management Authority; 05=Government extension officers; 06=Private climate services providers; 07=Internet/Website; 08=E-Mail; 09=SMS; 10=Phone call; 11=Meetings; 12=Traditional methods (specify); 13=Other (specify).*

17. Have you noticed any changes in the average temperature over the last 10 years?
    (If too difficult: Have you noticed a change in the number of hot days over the last 10 years?)

    01=. Increased 02= Decreased, 03=. Stayed the same 04= don't know

18. Have you noticed any changes in the average rainfall over the last 10 years?
    (If too difficult: Have you noticed a change in the number of rainfall days over the last 10 years?)

    01=. Increased 02= Decreased, 0 3 =. Stayed the same 04= don't know

19. Have the rain seasons been starting as expected over the last 10 years?
    (If too difficult: Have you noticed rains occurring starting and ceasing as expected over the last 10 years?)

    01=No 02=Yes 03= Don't Know

20. Are the rain seasons shorter or long over the last 10 years?

01= shorter 02= long 03= Don't Know 4= long and sometimes short

21. What changes have you observed on rainfall pattern and amount over the last 10years (Tick all that apply)

i. *Rains have become more erratic* [ ]
ii. *Rains come earlier* [ ]
iii. *Rains come later* [ ]
iv. *Rains are heavier* [ ]
v. *Longer periods of drought* [ ]
vi. *More floods* [ ]
vii. *Other, specify________________________*

22. Have you noticed any other changes apart from rainfall and temperature in climate over the last 10 years, __________01 = Yes, 2 = No *if yes, please specify*..

Objective 1 To examine the impacts of seasonal climate variability on livestock production and marketing

23. What is your perception on the impact of seasonal climate variability on the below decisions/activities in livestock production and marketing? (If too difficult: State your perception on the impact of the unexpected or prolonged or short seasons associated with change of seasons in the context of climate change on the below decisions/activities in livestock production and marketing).

Decision/Activity	Status of the Impact		
	02=Positive	01=Negative	00=I don't know
Livestock breeding plan			
Livestock productivity			
Livestock marketing time			
Number of livestock to sell			
Determining the price of livestock			
Pasture management			
Destocking and off-take			
Water management			
Disaster risk management			
Livestock herd size			
Livestock herd composition			
New livestock breed			
Fodder storage			
Livestock de-worming			
Control of livestock diseases			

24. What changes in practice have you or your family made to address the negative impacts in Q23 and over what period of time?

Negative impact on the following;	**Changes of practice**	**0-2 years,2-4 years, 4-6 years, 6-8 , 8-10 years , > 10**
Livestock breeding plan	1. 2. 3	
Livestock productivity	1. 2. 3	
Livestock marketing time	1. 2. 3	
Number of livestock to sell	1. 2. 3	
Determining the price of livestock	1. 2. 3	
Pasture management	1. 2. 3	
Destocking and off-take	1. 2. 3	
Water management	1. 2. 3	
Disaster risk management	1. 2. 3	
Livestock herd size	1. 2. 3	
Livestock herd composition	1. 2. 3	
New livestock breed	1. 2. 3	
Fodder storage	1. 2. 3	
Livestock de-worming	1. 2. 3	
Control of livestock diseases	1. 2. 3	

25. What indicators in the table below, have you observed for the last 10 years on the following aspects in your livestock production and marketing practices, because of seasons not occurring as expected?

(***Insert a tick where apply***)

Indicators	**Increase**			**Decrease**		
	Cattle	***Sheep***	***Goats***	***Cattle***	***Sheep***	***Goats***
Number of calves/kids per year						
Number of milk litres						
Average weight of individual animal						
Out-break of livestock diseases						
Herd size						
Change of breed						
Accessibility and availability of water						
Accessibility and availability of pasture						
Market accessibility						
Price of livestock						
Number of animals died of starvation						

27. From decisions/activities listed in the below table rank them starting with the most important to you as a livestock farmer?

Decision/ Activity	**Put a number against from the choices given(1,2,3,4,5,6 7,8,9,10,11)**
Livestock breeding plan	
Livestock Productivity	
Livestock marketing time	
Number of livestock to sell	
Determining the price of livestock	
Pasture management	
Destocking and off-take	
Water management	
Disaster risk management	
Livestock herd size	
Livestock herd composition	
New livestock breed	
Fodder storage	
Livestock de-worming	
Control of livestock diseases	

28. What is your view/observation on climate variability? 1] It is there, [2] It is not there [3] I don't know

29. What is your perception/opinion on the impacts of seasonal climate variability on the following livestock production performance. (If too difficult: What is the impact of the climate change on the performance of your livestock? *Tick what apply*

    i. *Milk* *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*
    ii. *Growth rate* *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*
    iii. *Fertility* *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*
    iv. *Calving rate* *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*
    v. *Calving interval* *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*

30. Indicate whether the below attributes for seasonal climate change in the table below had any adverse impact on your cattle, sheep and goats over the past 10 years? *(Tick what apply)*

Attributes for seasonal climate change	**Livestock (01=Yes, 00=No)**		
	1 [_cattle _]	**2 [_sheep _]**	**3 [goats_ _]**
More erratic rainfall	[__]	[__]	[__]
Reduction overall rainfall	[__]	[__]	[__]
Increase in overall rainfall	[_ _]	[_ _]	[_ _]
More frequent droughts	[_ _]	[_ _]	[_ _]
More frequent floods			
Strong winds	[_ _]	[_ _]	[_ _]
Late on-set of rains	[_ _]	[_ _]	[_ _]
Early on-set of rains	[_ _]	[_ _]	[_ _]
More frequent extreme Weather	[_ _]	[_ _]	[_ _]
Higher temperatures	[_ _]	[_ _]	[_ _]
Low temperatures	[_ _]	[_ _]	[_ _]

31. Have you made any changes in the way you manage your pasture or water for the last 10 years?

Yes [ ] No [ ]

If yes explain

……

……

……

Objective 2: To determine the performance of indigenous and conventional climate forecasts over the study period

32. Which seasonal weather forecasting information do you use in livestock production and marketing activities?

[1] Conventional/scientific [2] Indigenous/traditional [3] both [4] None

33. Is there a blend/mixture of indigenous/traditional and conventional/scientific seasonal weather forecasting techniques you are aware of? Yes [ ] No [ ]

34. If yes, briefly explain...

35. Indicate the Indigenous/traditional indicators, reliability in predicting or forecasting climate/weather events in the table below.

Climate/weather events	**Indictor (e.g. migration of birds)**	**Reliability/ other remarks**
―Short- rains‖ season		
―Long-Rains‖ Season.		
Dry season		
Rainfall intensity (above normal, normal and below normal)		
Floods		
Drought		
Landslide		
Thunder storms		
Seasonal rain distribution		
Expected rainfall onset and cessation dates		
Temperatures (maximum and minimum)		
El-nino (extreme rainfall causing havoc)		
La-Niñoa (extreme shortage of rainfall for a long time)		
Others specify		

Codes for reliability scale *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*

36. Indicate the reliability of conventional/scientific prediction of climate weather events in the table below

Climate/weather events	Reliability/ other remarks
―Short- rains‖ season	
―Long-Rains‖ Season.	
Rainfall intensity (above normal, normal and below normal)	
Floods	
Drought	
Landslide	
Thunder storms	
Seasonal rain distribution	
Expected rainfall onset and cessation dates	
Temperatures (maximum and minimum)	
El-nino	
La-Niñoa	
Others specify	

Codes for reliability scale *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*

37. How do you perceive climate change forecast, .has Indigenous forecast and the conventional forecast been efficient in your region ?
(Tick what apply)

Prediction	Efficiency
Indigenous forecast	[1] Very efficient [2] moderately efficient [3] not efficient [4] don‘t know
conventional forecast	[1] Very efficient [2] moderately efficient [3] not efficient [4] don‘t know

38. How effective have been the climate/weather forecast on the occurrence of the following climate change extreme events?
(Tick what apply)

Extreme Climate change events	Indigenous forecast	conventional forecast
Seasonal heat stress		
Droughts		
Flooding		
Disease epidemic		
Feed resource shortage		
Water resource decline		

[Scale: 4 = High variability to the actual; 3 = moderate variability to the actual; 2 = mild variability to the actual; 1 = No variability to the actual (exact)]

39. What are the reasons for preferring to use indigenous/traditional source for weather and climate information over convectional/scientific sources? (*list them starting with most important*)
   i. …………………………………………………
   ii. ……………………………………………………
   iii. …………………………………………………….
   iv. …………………………………………………….
   v. ……………………………………………………

40. What are the reasons for preferring to use conventional/scientific sources for weather and climate information indigenous/traditional over? (*list them starting with most important*)
   i. ……………………………………………………..
   ii. …………………………………………………………
   iii. …………………………………………………………..
   iv. …………………………………………………………..
   v. …………………………………………………………….

Objective 3: To establish the impact of indigenous and conventional seasonal weather forecasts on livestock production and marketing in a changing climate

41. Based on your experience what is your perception/opinion on the impacts of indigenous and conventional seasonal weather forecast information on the following livestock production performance. (If too difficult: What is the impact of the indigenous and conventional weather forecast on the performance of your livestock?

Production attributes	Impact of ITK forecast	Impact of conventional forecast
Milk		
Growth rate		
Fertility		
Calving rate		
Calving interval		

Codes: *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*

42. Based on your what is your perception/opinion on the impacts of indigenous and conventional seasonal weather forecast information on the following livestock marketing performance. (If too difficult: What is the impact of the indigenous and conventional weather forecast on the marketing of your livestock?

Marketing attributes	Impact of ITK forecast	Impact of conventional forecast
Sales in auction yards		
Sales outside the sub-county		
Sale prices		
Number of livestock sold		
Purchase of livestock		
Purchasing price		

Codes: *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*

43. According to your experience as a livestock farmer, indicate the impact of indigenous and conventional and both ITK and conventional seasonal climate forecast information on the following decision/activities listed in the table below?

Decision/ Activity	Impact of ITK Forecast	Impact of conventional forecast
Livestock breeding plan		
Livestock Productivity		
Livestock marketing time		
Number of livestock to sell		
Determining the price of livestock		
Pasture management		
Destocking and off-take		
Water management		
Disaster risk management		
Livestock herd size		
Livestock herd composition		
New livestock breed		
Fodder storage		
Livestock de-worming		
Control of livestock diseases		

Codes: *[1] low, [2] fair, [3] good, [4] very good, [5] excellent*

44. Change in herd / flock size dynamics in comparison to 10 years ago
Fill in the table below in relation to the number of animals owned by the household 10 years ago. Strike out the column if the species is not relevant to the household (i.e. the household doesn't keep the species now or in the past)

	Cattle			Sheep			Goats		
Does the household own more/less animals than 10 years ago? (code)									
Does the household own more/less of these breeds than 10 years ago? (code)	Exotic	Indigenous	Others	Exotic	Indigenous	Others	Exotic	Indigenous	Others
CHANGE CODES: 0 = no change, 1 = more, 2 = less									

Objective 4: To recommend interventions to enhance efficiency and effectiveness in livestock production and marketing in the context of climate change.

45. What suggestions can you give to reduce adverse impacts of seasonal climate variability in order to enhance livestock production and marketing in your household?

Livestock production

a) ....
b) ....
c) ....
d) ....

Livestock marketing

a) ....
b) ....
c) ....

46. What opportunities are there in livestock production and marketing as a result of seasonal climate variability?

Livestock production

a)..
b)..
c)..
d)..

Livestock marketing

d) ....
e) ....
f) ....
g) ....

47. What suggestions can you give to improve the indigenous/traditional and conventional/scientific weather and climate forecasts (predicted weather and climate information) for the period you have used them?

Indigenous/Traditional

a..
b..
c..
d

Conventional/Scientific

a...
b...
c..
d...

48. Based on your experience with Indigenous/Traditional and conventional/scientific weather and climate information, suggest ways to reduce the adverse impact of this information on livestock production and marketing?

Indigenous/Traditional

a..
b..
c..
d

Conventional/Scientific

a...
b...
c..
d...

49. Based on your experience with Indigenous/Traditional and conventional/scientific weather and climate information, suggest points of interventions to enhance reliability of the information

Indigenous/Traditional

a..
b..
c..
d. …………………………………………………..

Conventional/Scientific

a..
b..
c...
d..

50. What weather/climate information events based on the livestock production and marketing operations would you strikes to receive? (Tick all that apply)

a) On-set of rains [ ]
b) Cessation of rains [ ]
c) Flood forecast [ ]
d) Drought forecast [ ]
e) Choice of pastures [ ]
f) Pest and or disease outbreaks [ ]
g) Other (specify)______________________[ ]

51. What would be your preferred source of weather and climate information
a) Indigenous/traditional
b) Conventional/scientific
c) Both
d) Others, specify...

52. What would be your preferred medium for delivery of weather and climate information?

a) Radio [ ]
b) SMS [ ]
c) Internet [ ]
d) National daily newspaper [ ]
e) Community bulletin [ ]
f) Public meeting (Baraaza) [ ]
g) Traditional rain makers announcements [ ]
h) Other __________________________ [ ]

53. Would you or your family be willing to pay for weather and climate information to support the decisions you make in your livestock production and marketing activities?
Yes [ ] No [ ]

Thank you for your time

God bless you

Appendix 1b: Summarized Characteristics of the Respondents in House Survey

Gender of the Respondent

Gender of the Respondent	**Frequency**	**Percent**
Male	247	60,0
Female	165	40.0
Total	**412**	**100**

Education level/status of the respondent

Education level/status	**Frequency**	**Percent**
No Education at all	63	15.1
Primary	129	30.9
Secondary	145	34.8
Post Secondary	80	19.2
Total	**417**	**100**

Household type for the respondent

Household Type	**Frequency**	**Percent**
Husband married headed household	385	90.4
Male headed, Single headed household	15	3.5
Female headed, Single headed household	20	4.7
Female headed, husband away headed household	6	1.4
Total	**426**	**100**

Primary occupation or source of the livelihood of the respondent

Livelihood	**Frequency**	**Percent**
Livestock keeping alone	39	9.6
Livestock keeping and crops	353	86,9
Trading	14	3.4
Total	**406**	**100.0**

Appendix 2: Key Informant Interview Guide

For Key Informant Interview Guide

Soliciting views of Key Informants on Impacts of Seasonal Climate Variability and Weather Forecasts on Livestock Production and Marketing in Baringo County, Kenya

Sub-County Name ________________________

Background information
Name of Respondent:____________________ Date of Interview:____________________

Position of Respondent:___________________ Name of Interviewer:_________________

Respondent‘s Institution:__________________ Interviewer contact (mobile phone) _____

In the introduction, the interviewer explains the following to the respondent:

I/We have requested an interview with you because we believe that in your position as [*position/job title*] in [*name of office*], you are in a position to provide us with useful perspectives and insights on seasonal weather forecasts/livestock production and marketing issues, and I/We look forward to learning from you today. I/We have some guiding questions, but we want you to feel free to talk about anything you think is important for us to know. I/We will be taking notes as we talk to be sure I/We don‘t miss anything. Is that alright with you?

YES________________ NO___________________

Discuss and explore the following issues as exhaustively as possible with the respondent (*Note: Not all issues need to be discussed with all the respondents*)

1. Briefly tell us about your organization in relation to seasonal climate variability and weather forecasts on livestock production and marketing

2. In your opinion what do you consider to be the impact of seasonal climate and weather forecasts on the livestock production and marketing performance in the sub-county

3. Briefly tell us about traditional or indigenous and conventional climate/weather forecasts in this Sub-County for the last ten year or more. In your opinion what do you consider to be more reliable forecast between the two and why?

4. What are your interests as an organization/institution in accessing the climate/weather forecast information?

5. In your view what are the major impacts of indigenous and that of conventional seasonal weather forecasts on livestock production and marketing in a changing climate.

6. What are the major challenges facing the livestock production and marketing in the sub-county?

7. What do you think should be done to enhance efficiency and effectiveness in livestock production and marketing in the context of climate change:

8. What do you think should be done for the livestock farmers to adopt seasonal climate forecast management in their livestock production and marketing activities in your Sub-county?

9. Is there anything else you would strikes to let us know as far as climate change, livestock and marketing are concerned?

Thank you for your time

Appendix 3: Focus Group Discussion Guide

Focus Group Discussion Guide

Data collection from focus groups discussion on impacts of seasonal climate variability and weather forecasts on livestock production and marketing in Baringo county, Kenya

Sub-County Name ___________________________

Background information

Name of interviewee:__________________________ Date of interview:______________________

Name of Focus Group:_________________________ Number of members:___ (M=___ ,F= ___)

Type of Group (Women, Youth, Special, Mixed/Others-specify): __________________________

For the different focus groups that the Researcher will identify, the following checklist will act as a guide for the Focus Group Discussions. For each group include a list of the participants and the special groups they represent.

Checklist

Introductory Questions

1. What are the five major economic activities people in your area are involved in?
2. What are the five important livestock commodities (cattle/sheep and goats) in your area and why are they important?

Impacts of seasonal climate variability on livestock production e.g. Prolonged dry season, short rainfall or prolonged long rainfall season

3. What are the five major effects of seasonal climate variability in the contexts of climate change on each of the following decisions/activities in livestock production
    a) Livestock breeding plan
    b) Livestock productivity
    c) Pasture management
    d) Control of livestock diseases
    e) Livestock de-worming
    f) Livestock herd size
    g) New livestock breeds
    h) Destocking and off-take
4. Briefly explain **two ways**/interventions the effects on each of the above activities/decisions are being addressed by farmers

Impacts of seasonal climate variability on livestock marketing

5. Explain how seasons relate to livestock marketing in your area e.g. how the demand and supply is in Dry spell, long rain season and short rains. How is the behavior of the market in

the above mentioned seasons and what type animals and who are participants in the respective seasons?

6. What are the five major effects of seasonal climate variability on each of the following decisions/activities in livestock marketing
    a) Livestock marketing time
    b) Number of livestock to sell
    c) Pricing of livestock
    d) Demand and supply
7. Briefly explain **two ways**/interventions the effects on each of the above activities/decisions are being addressed by farmers

Performance of Indigenous and Conventional climate forecasts

8. Which is the most reliable between the two weather/ climate forecasts above?
9. What are the five major advantages of each of the two above forecasts?
10. What are the five major disadvantage of each of the two above forecasts?

Impacts of Indigenous and Conventional climate forecasts of livestock production

11. Based on your experience, when, why and how has the indigenous weather/climate forecast impacted on the livestock production.
12. Based on your experience, when, why and how has the conventional climate forecast impacted on the livestock production

Impacts of weather forecast on livestock production

13. Explain how seasons relate to productivity in livestock e.g. Which activities in Dry spell, long rain season and short rains
14. Which climate change coping strategies are used by different livestock actors (farmers, transporters, traders, etc) in your area

General

15. Please make any other comments/suggestions on how to improve livestock production and marketing in the context of climate change?

[Finally, thank the group for sparing their precious time to meet with you and deliberate with you on the various issues]

Appendix 4: GPS Points of Households Interviewed in Mochongoi Ward, Marigat Sub-County in Baringo County

S/N	Longitude	Latitude	Elevation	S/N	Longitude	Latitude	Elevation
1	36.07648	0.40118	1018	29	36.03097	0.38014	1007
2	36.06931	0.34958	1005	30	36.03634	0.37558	1000
3	36.06256	0.34194	1029	31	36.04109	0.37395	1013
4	36.0646	0.35425	1010	32	36.04279	0.36979	1018
5	36.0637	0.34149	1027	33	36.04482	0.36199	1016
6	36.0627	0.3461	1009	34	36.04832	0.35771	1020
7	36.08307	0.39102	1027	35	36.052	0.35806	1008
8	36.0833	0.39262	1029	36	36.05621	0.3575	1019
9	36.07861	0.39569	1021	37	36.05936	0.35761	1021
10	36.07772	0.39869	1022	38	36.08397	0.3831	1023
11	36.07508	0.35433	1015	39	36.08595	0.39019	1034
12	36.06982	0.35362	1008	40	36.08373	0.39245	1033
13	36.07789	0.35669	1019	41	36.08585	0.3861	1033
14	36.07972	0.35749	1010	42	36.07757	0.39778	1019
15	36.06533	0.34009	1031	43	36.08697	0.38744	1034
16	36.07876	0.358	1014	44	36.0761	0.40365	1017
17	36.07676	0.35731	1022	45	36.06637	0.34844	1002
18	36.07381	0.3567	1017	46	36.0631	0.35487	1010
19	36.07284	0.35608	1036	47	36.06466	0.3542	1011
20	36.06869	0.35443	1008	48	36.0828	0.35215	1025
21	36.0631	0.34013	1035	49	36.07965	0.37919	1023
22	36.07028	0.41197	1011	50	36.07647	0.3779	1018
23	36.0844	0.38967	1036	51	36.08474	0.3912	1035
24	36.08508	0.38672	1033	52	36.07394	0.37669	1017
25	36.08026	0.39312	1025	53	36.06817	0.37425	1011
26	36.08448	0.39178	1030	54	36.06707	0.37111	1010
27	36.08098	0.39286	1031	55	36.06721	0.36617	1005
28	36.08184	0.39244	1025	56	36.06702	0.36117	1007
				57	36.06631	0.35541	1007
				58	36.0727	0.40872	1009
				59	36.07503	0.35916	1018

Appendix 5: GPS Points of Households Interviewed in Mokutani Ward, Marigat Sub-County in Baringo County

S/N	Longitude	Latitude	Elevation	S/N	Longitude	Latitude	Elevation
1	36.113	0.45303	1021	43	36.10688	0.46221	992
2	36.10797	0.4569	1021	44	36.11341	0.47767	995
3	36.10458	0.45419	1007	45	36.11102	0.47173	997
4	36.0882	0.45664	990	46	36.10983	0.46855	995
5	36.0856	0.45525	993	47	36.10719	0.46417	971
6	36.08305	0.45318	991	48	36.10119	0.46417	971
7	36.09196	0.43922	1001	49	36.12895	0.44985	1100
8	36.09456	0.43922	1006	50	36.10413	0.45847	996
9	36.07959	0.43323	1010	51	36.07795	0.43002	1021
10	36.08681	0.45121	991	52	36.08194	0.44067	993
11	36.08137	0.44555	993	53	36.07684	0.42184	992
12	36.21484	0.61605	1175	54	36.08058	0.43526	997
13	36.17116	0.5585	1160	55	36.08303	0.45316	998
14	36.24963	0.62998	1165	56	36.08792	0.45647	992
15	36.08681	0.45121	991	57	36.07735	0.42857	1018
16	36.11908	0.536	999	58	36.08551	0.4552	990
17	36.1644	0.55627	1212	59	36.08121	0.44681	994
18	36.24982	0.63347	1194				
19	36.08651	0.44172	992				
20	36.1105	0.42183	1030				
21	36.09927	0.43412	1016				
22	36.24964	0.62997	1173				
23	36.24894	0.63038	1173				
24	36.24877	0.63038	1173				
25	36.08207	0.44116	992				
26	36.10398	0.42621	1028				
27	36.24963	0.62998	1165				
28	36.10145	0.43	1022				
29	36.09645	0.43582	1009				
30	36.10944	0.45439	1008				
31	36.12804	0.44982	1071				
32	36.12818	0.44875	1082				
33	36.13163	0.44838	1085				
34	36.13163	0.44942	1085				
35	36.10503	0.45745	1000				
36	36.10608	0.45637	1004				
37	36.10212	0.4565	995				
38	36.10546	0.45519	1004				
39	36.11177	0.47499	996				
40	36.0928	0.45651	987				
41	36.11086	0.47251	995				
42	36.12897	0.44974	1125				

Appendix 6: GPS Points of Households Interviewed in Marigat Ward, Marigat Sub-County in Baringo County

S/N	Longitude	Latitude	Elevation	S/N	Longitude	Latitude	Elevation
1	35.82673	0.25614	1582	41	36.19397	0.35875	1840
2	35.86628	0.287	1454	42	36.22492	0.35875	1820
3	35.85897	0.2863	1495	43	36.24473	0.42298	1770
4	35.84464	0.27518	1550	44	36.25486	0.50224	1720
5	35.83908	0.2728	1563	45	35.8101	0.27785	2010
6	35.83765	0.26547	1565	46	35.82345	0.26816	1727
7	35.83219	0.26499	1582	47	35.85304	0.27804	1516
8	36.01397	0.04698	1020	48	35.8629	0.29159	1456
9	36.04219	0.42274	1000	49	35.86773	0.29474	1490
10	36.068	0.42686	1005	50	35.88184	0.29746	1547
11	36.07678	0.4353	1050	51	35.88638	0.32547	1511
12	36.13179	0.39577	1087	52	35.88362	0.34606	1458
13	36.13488	0.41003	1100	53	35.8921	0.34547	1479
14	36.13828	0.42957	1200	54	36.01193	0.4854	1030
15	36.1815	0.43714	1220	55	35.9712	0.48967	1025
16	36.18367	0.46075	1200	56	36.02785	0.47425	1020
17	36.18577	0.48849	1000	57	36.01647	0.42608	1050
18	36.18626	0.51043	1010	58	35.97037	0.47693	1057
19	36.16677	0.50083	1020	59	35.9712	0.48956	1025
20	36.14593	0.4919	1030	60	35.96011	0.48609	1035
21	35.97427	0.07203	2100	61	35.96315	0.49434	1000
22	35.92272	0.06847	2005	62	36.05849	0.50692	1050
23	35.93478	0.06262	1650	63	36.14156	0.40125	1065
24	35.97394	0.06102	1700	64	36.14902	0.42984	1030
25	35.97394	0.0177	1705	65	36.16582	0.48364	1011
26	35.94412	0.05337	1800	66	36.16508	0.51534	1000
27	35.95311	0.04085	1750	67	35.3789	0.4317	1077
28	35.92337	0.00317	1700	68	35.6378	0.5003	1003
29	35.91471	0.0118	1600				
30	35.94482	0.02426	1650				
31	35.95939	0.02427	1635				
32	35.94419	0.04569	1700				
33	35.15671	0.51635	1005				
34	36.12283	0.52257	1000				
35	36.08234	0.5219	2005				
36	36.08474	0.5132	1650				
37	36.07236	0.51562	1620				
38	36.06416	0.5164	1700				
39	36.04171	0.5122	1800				
40	36.13426	0.3647	1905				

Appendix 7: GPS Points of Households Interviewed in Iichamus Ward, Marigat Sub-County in Baringo County

S/N	Longitude	Latitude	Elevation	S/N	Longitude	Latitude	Elevation
1	36.07774	0.42977	1024	43	35.99992	0.58269	1017
2	36.0016	0.44089	1013	44	36.00373	0.59931	1005
3	36.02789	0.45659	1005	45	35.99557	0.57906	1035
4	36.02259	0.45296	1009	46	36.00373	0.59633	1005
5	36.04967	0.41121	1000	47	35.99163	0.5652	1025
6	36.0745	0.42359	998	48	36.00887	0.60327	977
7	36.01519	0.44692	1000	49	36.05986	0.45392	996
8	36.07305	0.42041	999	50	36.0438	0.471	996
9	36.01891	0.45106	1008	51	36.00249	0.59633	1016
10	35.99929	0.43864	1021	52	35.99902	0.58582	1015
11	36.0615	0.41353	999	53	35.99453	0.57344	1015
12	36.06749	0.45352	987	54	36.05278	0.47697	994
13	36.05457	0.45359	996	55	36.0574	0.49273	990
14	36.03442	0.45447	1000	56	36.05706	0.48961	991
15	36.04444	0.45634	998	57	36.05577	0.4871	993
16	36.07335	0.40848	1009	58	36.0544	0.48453	994
17	36.04541	0.45637	1003	59	36.05397	0.48124	990
18	36.03729	0.45366	1002	60	36.05458	0.47873	1004
19	36.05693	0.45331	997	61	36.05198	0.47595	999
20	36.06924	0.41267	997	62	36.04887	0.47429	997
21	36.04258	0.45547	997	63	36.04481	0.47123	1028
22	36.03978	0.45413	999				
23	36.03024	0.45473	1001				
24	36.07294	0.45293	989				
25	36.06916	0.41272	1003				
26	36.06245	0.41984	994				
27	36.04132	0.41523	998				
28	36.05499	0.4146	997				
29	36.06533	0.41851	999				
30	36.0236	0.42166	1006				
31	36.01635	0.42111	1009				
32	36.07151	0.41091	1008				
33	36.06847	0.41528	999				
34	36.01243	0.42295	1012				
35	36.06916	0.41272	1003				
36	36.009	0.60159	983				
37	36.01022	0.59693	973				
38	36.00199	0.57954	996				
39	36.01011	0.5926	971				
40	36.0108	0.58718	978				
41	36.00446	0.58198	986				
42	35.99917	0.58009	1002				

Appendix 8: GPS Points of Households Interviewed in Kisanana Ward, Mogotio Sub-County in Baringo County

S/N	Longitude	Latitude	Elevation	S/N	Longitude	Latitude	Elevation
1	36.09768	0.0166	1617	43	36.0056	0.1005	1570
2	36.09795	0.02672	1580	44	36.01584	0.1148	1509
3	36.0992	0.04167	1566	45	36.00815	0.12511	1498
4	36.09882	0.05499	1551	46	35.96215	0.12064	1487
5	36.10254	0.06975	1548	47	35.96977	0.07008	1518
6	36.102	0.08087	1538	48	35.97096	0.05759	1536
7	36.10303	0.09247	1533	49	35.98038	0.13443	1481
8	36.10401	0.10182	1525	50	35.99381	0.46876	1021
9	36.16717	0.11014	1518	51	35.99253	0.15792	1474
10	36.16977	0.12691	1519	52	36.03035	0.11654	1481
11	36.11487	0.13583	1509	53	36.04469	0.13557	1412
12	36.11942	0.14333	1513	54	36.03904	0.21371	1316
13	36.12207	0.15404	1523	55	36.05804	0.15662	1373
14	36.12831	0.16432	1533	56	36.04662	0.09117	1530
15	36.13503	0.17253	1547	57	36.04949	0.07706	1554
16	36.13508	0.18602	1571	58	36.0439	0.12118	1433
17	36.14193	0.19478	1607	59	36.03655	0.09417	1499
18	36.14519	0.20239	1638	60	36.05506	0.18397	1341
19	36.14878	0.21889	1635	61	36.0395	0.17954	1362
20	36.14407	0.22357	1649				
21	36.13882	0.22372	1636				
22	36.13701	0.22055	1651				
23	36.07558	0.0573	1683				
24	36.0786	0.07792	1705				
25	36.07789	0.11282	1695				
26	36.08416	0.08506	1676				
27	36.09023	0.09965	1609				
28	36.09106	0.11335	1597				
29	36.09696	0.11928	1610				
30	36.08708	0.07019	1678				
31	36.0824	0.05289	1688				
32	36.07582	0.04451	1685				
33	36.02577	0.08773	1530				
34	36.04818	0.20238	1357				
35	36.0566	0.11263	1454				
36	36.00389	0.06923	1561				
37	36.00618	0.06337	1572				
38	36.02851	0.02121	1645				
39	36.04364	0.03367	1675				
40	36.01828	0.04548	1605				
41	36.04964	0.06244	1595				
42	36.0908	0.09122	1589				

Appendix 9: GPS Points of Households Interviewed in Emining Ward, Mogotio Sub-County in Baringo County

S/N	Longitude	Latitude	Elevation	S/N	Longitude	Latitude	Elevation
1	35.90183	0.2032	1554	42	35.94572	0.26887	1370
2	35.89913	0.16752	1592	43	35.9465	0.25647	1380
3	35 89433	0.16725	1602	44	35.92443	0.2936	1390
4	35.89215	0.12085	1593	45	35.9292	0.31743	1366
5	35.87498	0.13273	1596	46	35.94075	0.23662	1398
6	35.87155	0.13513	1609	47	35.8942	0.20773	1549
7	35.87232	0.13882	1610	48	35.93273	0.3815	1352
8	35.87253	0.13947	1609	49	35.93318	0.32522	1357
9	35.87122	0.14587	1631	50	35.8977	0.24878	1492
10	35.86998	0.14822	1632	51	35.9176	0.22231	1521
11	35.86955	0.15793	1628	52	35.9161	0.28523	1449
12	35.86902	0.1592	1626	53	35.89557	0.22805	1535
13	35.8733	0.15478	1617	54	35.92258	0.30053	1396
14	35.87598	0.15233	1603	55	35.92725	0.28775	1391
15	35.8769	0.15157	1597	56	35.92932	0.2797	1372
16	35.88313	0.14532	1578	57	35.9426	0.2621	1346
17	35.87947	0.1454	1580	58	35.90612	0.25528	1489
18	35.8807	0.13235	1584	59	35.93833	0.27977	1394
19	35.88462	0.13937	1580	60	35.9286	0.30492	1373
20	35.8793	0.12788	1588	61	35.90358	0.1981	1562
21	35.88148	0.12095	1598	62	35.912	0.22555	1549
22	35.88698	0.12067	1589	63	35.90537	0.2223	1520
23	35.89235	0.12035	1588	64	35.90342	0.26517	1512
24	35.89293	0.12832	1587	65	35.88907	0.21613	1543
25	35.89205	0.13443	1584	66	35.89942	0.19435	1566
26	35.8954	0.14203	1585	67	35.9432	0.27723	1347
27	35.90267	0.12965	1589	68	35.9214	0.28913	1386
28	35.91007	0.11668	1583	69	35.90368	0.24715	1488
29	35.91962	0.11338	1582	70	35.9101	0.2681	1488
30	35.926	0.11873	1584	71	35.8976	0.21545	1524
31	35.90247	0.14912	1597	72	35.8755	0.22455	1523
32	35.90498	0.13807	1599				
33	35.90268	0.15468	1598				
34	35.90933	0.27502	1492				
35	35.9352	0.3622	1311				
36	35.9386	0.37828	1279				
37	35.9017	0.25598	1520				
38	35.9069	0.26005	1492				
39	35.89707	0.23645	1521				
40	35.921	0.27162	1432				
41	35.9402	0.24523	1395				

Appendix 10: GPS Points of Households Interviewed in Mogotio Ward, Mogotio Sub-County in Baringo County

S/N	Longitude	Latitude	Elevation	S/N	Longitude	Latitude	Elevation
1	35.907818	-0.37151	1760	42	35.944119	-0.055371	1800
2	35.903151	-0.049728	1800	43	35.9465	-0.045688	1700
3	35.905766	-0.046766	2140	44	35.953115	-0.040847	1750
4	35.90592	-0.4114	1980	45	35.923371	0.003166	1700
5	35.902642	-0.033177	1625	46	35.914713	0.011804	1600
6	35.900575	-0.24908	1610	47	35.944821	0.02426	1650
7	35.896781	-0.2080	1765	48	35.959392	0.024274	1635
8	35.885745	-0.021805	2025	49	35.814615	0.012735	1700
9	35.917492	-0.03457	1620	50	35.824599	0.003794	1705
10	35.900023	-0.045242	1750	51	35.828127	0.033384	1600
11	35.871027	-0.02728	2025	52	35.841911	0.03632	1650
12	35.870426	-0.30521	1900	53	35.859446	0.033383	2100
13	35.872375	-0.31763	1800	54	35.88855	0.016516	2000
14	35.856214	-0.29727	1850	55	35.875016	0.027883	2105
15	35.856214	-0.24972	1700	56	35.862963	0.039938	1900
16	35.857262	-0.036521	1820	57	35.871226	0.02926	1905
17	35.890355	-0.023444	1920	58	35.907436	0.001012	1950
18	35.876329	-0.18317	1865	59	35.90088	0.01205	1900
19	35.887101	0.02028	1680	60	35.877436	0.035117	2100
20	35.914775	-0.01096	1790	61	35.859232	-0.23744	1700
21	35.855511	-0.014122	1760	62	35.8654	-0.18367	1725
22	35.892608	-0.01236	1680	63	35.876442	-0.002391	1680
23	35.908489	0.352931	1940	64	35.871889	-0.017578	1790
24	35.879882	0.01518	1830	65	35.879906	-0.018604	1800
25	35.940708	-0.006954	1650	66	35.862989	-0.002674	1830
26	35.941746	0.003073	1670	67	35.840252	-0.009634	1900
27	35.928262	-0.009379	1635	68	35.886828	0.016443	1930
28	35.93725	0.001688	1730	69	35.916155	0.018354	1780
29	35.3424	-0.004889	1745	70	35.919433	0.005595	1860
30	35.930336	-0.004535	1980	71	35.911469	0.019196	1895
31	35.915764	-0.004535	2100	72	35.901655	0.022134	1900
32	35.922331	0.038072	1900				
33	35.923023	-0.049826	1905				
34	35.938935	0.082332	1605				
35	35.925786	0.02451	1730				
36	35.974268	0.007901	1735				
37	35.974268	0.07203	2100				
38	35.922716	-0.068486	2005				
39	35.934779	-0.062624	1650				
40	35.975301	0.000054	1700				
41	35.973936	0.017702	1705				

Appendix 11: Challenges Encountered during Data Collection in the Study Area

Mogotio Sub-county

A) Kisanana Ward

i. Language barrier-passing information unaltered

ii. Transportation-Roads routes challenges

iii. Respondent not willing to answer point questions

iv. Respondents having no time to respond

v. Extreme temperatures around lake Bogoria causing headache

vi. Some respondents not willing to give sufficient time

vii. Doubling intensions of the data

viii. Terrain roads too rough

ix. Hostility- think collections animals size for county taxation system

x. Motorcycle broke down

xi. People refuse to give out information because of fear of unknown

B) Emining Ward

i. Absence of households inaccessible areas

ii. Terrain-poor roads

iii. Insecurity due cattle rustling

iv. Language barrier

v. Explain every details

vi. Questionnaire translation

vii. Farmers hostility

vi Extreme temperatures

ix. Poor road network

x. Respondents refuse to give information

C) Mogotio Ward

i. Harsh weather

ii. Busy respondents

iii. Uneven terrain

iv. Wrong answers or denied information

v. Farmers not willing to answer all the questions

vi. Some farmers were un-cooperative

vii. Farmers took long to answer questions

viii. Some farmers not comfortable answering repetitive questions

ix. Sparsely populated had to cover large millage to get livestock farmers

Marigat (Baringo South Sub-county) A)Mokutani Ward

i. Poor road network caused by heavy rains

ii. Unwilling respondents to respond to some questions due to traditional belief

iii. Insecurity in some parts

iv.Illiteracy among some respondents

v . Hostile respondents

vii.Time consuming answers not related to the questionnaires

viii Mechanical problems with motorbITKe

x. Scattered settlement

xi. Language barrier among some respondents

xii. Disclosure of some information by some respondents

B) Mochongoi Ward

i. Insecurity

ii. Poor communication networks

iii.Unwilling respondents who are dishonesty and insincere

iv.Heavy rains some times

v.Harsh and difficulty terrain

vii. Transport problem

C)Ichamus Ward

i. Un-wlling respondents

ii.Poor road network

iii. Unfavourable terrain

iv.Insecurity in some parts eg. Longewani sub-location

v.Poor communication network

vii. Greatly engaged respondents

viii. uncooperative respondents

x.Network problem

Marigat Ward

i. Un-wlling respondents

ii.Poor road network

iii. Unfavourable terrain

iv.Insecurity in some parts

v.Poor communication network

vii. Greatly engaged respondents

viii. uncooperative respondents

x.Network problem

Appendix 12: Areal Rainfall/Thiessen Value/Weighted Averages for 6-Set Meteorological Stations

	Talai	Perkerra	Chemususu	Kimose	Snake Farm	Lake Bogoria	Total Area	Areal rainfal/thiessen value Value/Weighted	Average)
Area(km2)	800.355	680.039	348.842	889.485	306.724	880.314	3905.759		
year									
1974	1270.4	736.9	1132.5	857	493.4	674.1		875.6304	615.3043
1975	1301.7	770.8	1212	1212	904.1	420		950.8752	
1976	853.7	476.7	1003.7	897.5	476.7	610		726.8984	
1977	1576.5	1086.5	1715.6	1200.7	1101.5	935.7		1236.294	
1978	1486.2	807.3	1131.3	1087.8	804.8	1009.7		1084.658	
1979	1395.9	757.9	1152.2	879.8	623	885.7		969.8256	
1980	1106.9	410	972.7	571	492.7	498		666.0582	
1981	1602	679.4	1356.3	365.2	1062	531.9		854.1596	
1982	1761.8	671.2	1394.7	1013.8	623	689.6		1037.686	
1983	1489.4	681.4	1313.7	793.8	720	703.5		937.0564	
1984	445.2	264.8	655.7	408.2	191.5	247.1		359.5918	
1985	1296.4	714.6	1428.6	971.9	742	628.8		939.0013	
1986	951.4	506.5	936.5	802	723	591.9		739.6192	
1987	1408.1	585.1	1027.5	728.4	592.3	596.6		829.0513	
1988	2281.3	892.9	1394.2	1153.6	1114.6	891.5		1298.646	
1989	2144.2	880	1148.8	995.5	778.8	855.2		1175.83	
1990	1276.5	548.6	1164.9	746.1	475.9	814		851.8905	
1991	1209.9	662.8	1107.4	836.4	523.7	666.7		844.1097	
1992	1344.4	565.3	899.5	587.7	463	368.5		707.5106	
1993	919.6	552.2	1080.4	763.3	551.1	480.7		706.536	
1994	1007.1	580.1	1256.6	980.3	613.1	630.7		833.1573	
1995	843.9	424.4	865.1	729.9	463.7	506.2		640.8202	
1996	1653.5	565	1214.3	1002.4	679.1	606.9		964.0601	
1997	1687.6	760.1	1099.6	1340.8	837.8	956		1162.985	
1998	1312.7	486.7	1288.5	997.3	816.9	864.5		954.939	
1999	949.3	495.7	820.7	585.8	479.8	594		659.1036	
2000	765.5	310.3	759.9	597.1	598.2	499.9		574.3917	
2001	1046.5	494	1122.6	1115.8	691.7	664.7		858.9659	
2002	751.9	570.1	1223.8	727.8	592.9	338.5		651.2435	
2003	1140	432.2	1295.5	766.7	1662.4	990.1		952.8769	

Appendix 13: An Extract of Seasonal Rainfall Advisories for Mogotio Sub-county in Baringo County

MOGOTIO SUB-COUNTY

Agriculture

BELOW NORMAL	NORMAL	ABOVE NORMAL
Potential Impacts ➢ Upsurge of pests-Aphids, stalk borers and red spider mites *Mitigation Measures* 1. Grow drought tolerant crops (THVC- Traditional High Value Crops) such as sorghum, green grams, cowpeas, groundnuts, finger millet sweet potatoes and cassava 2. Grow drought escaping crop varieties such as the Katumani beans(B1-B9) and Katumani maizeDHO4/DHO2 3. Use of 23:23:0 fertilizers and topdressing with CAN and use of manure is highly encouraged - Avoid 17:17:17 fertilizers 4. Practice conservation agriculture-zero, minimum tillage 5. Do water harvesting 6. Apply chemical weeding 7. Encourage vegetable and food preservation 8. Establish multi storey gardens. 9. Gapping/replant in cases of crop failure	*Potential Impacts* ➢ Upsurge of pests-Aphids, stalk borers and red spider mites *Mitigation Measures* 1. Grow drought tolerant crops (THVC) such as sorghum, green grams, cowpeas, groundnuts, finger millet sweet potatoes and cassava. 2. Grow drought escaping crop varieties such as the Katumani beans(B1-B9) and Katumani maizeDHO4/DHO2 3. Use 17:17:0 fertilizers and do minimal top-dressing- Avoid 17:17:17 fertilizers. 4. Use of manure is highly recommended 5. Practice conservation agriculture-zero/ minimum tillage 6. Do water harvesting 7. Apply chemical weeding 8. Encourage vegetable and food preservation 9. Establish multi storey gardens. 10. Gapping/replant in cases of crop failure	*Potential Impacts* ➢ Land/mudslides *Mitigation Measures* 1. Do early land preparation 2. Do early planting 3. Plant normal crops 4. Use of manure is highly recommended 5. Avoid areas prone to water logging and land/ mudslides 6. Construct soil conservation structures i.e. cut-off drains 7. Plant fruit trees 8. Do agro forestry 9. Do water harvesting 10. Use of 17:17,.fertilizers and do minimal topdressing- Avoid 17:17:17 fertilizers 11. Do crop diversification.

Livestock

BELOW NORMAL	NORMAL	ABOVE NORMAL
Potential Impacts ➢ Reduced body condition and productions *Mitigation Measures* 1. Establish drought resistant grasses-dual purpose sorghum, cow candy and Sudan grass. 2. Practice timely off take of livestock 3. Practice rotational grazing / paddocking 4. Pasture and fodder	*Potential Impacts* ➢ Unfavourable animal body condition and production *Mitigation Measures* 1. Pasture and fodder establishment. 2. Pasture and fodder conservation-hay and silage 3. Moderate restocking 4. Rotational grazing / paddocking 5. Do diversification-beekeeping,	*Potential Impacts* ➢ Unfavourable animal body condition and production *Mitigation Measures* 1. Pasture and fodder establishment. 2. Pasture and fodder conservation-hay and silage 3. Restocking 4. Rotational grazing / paddocking 5. Do diversification -

Appendix 14: Livestock Product to the Market

Monday, May 18, 2015 / The Standard

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LINKING LIVESTOCK PRODUCTS TO THE MARKET

MIFUGO NI MALI

A KCB FOUNDATION PROGRAMME

Livestock trade in Kenya is dominated by private entrepreneurs who operate as a marketing chain. They source and bulk the livestock numbers for delivery to terminal markets. Although the marketing chain is well known by the livestock producers and other value chain actors, the economic and institutional barriers to livestock trade are holding back this multi-billion shilling industry.

Market infrastructure to facilitate trade is required for all agriculture produce. Majority of the markets in Kenya are in a dire situation and livestock markets are in the worst state. They are characterised by make-shift structures that are not fit for purpose and notorious for poor health, safety and hygiene standards. It is no surprise that such markets catalyze the spread of disease and parasites that compound productivity challenges plaguing the sector.

To facilitate trade, accessible and safe market spaces, which integrate technology and designed with the customer in mind are required. In line with this the KCB Foundation through the Mifugo Ni Mali programme is working with cooperative societies and County Governments to modernize market infrastructure and systems to better serve the customers. Some of the beneficiaries include Kiptomoe Farmers Cooperative Society Limited in Baringo and Mzizwa Taita Dairy Cooperative Society from Taita Taveta. The societies received interest-free loans of KES 5.6 million and KES 1.7 million respectively to buy and install milk dispensers in Kabarnet and Voi towns. The purpose being to ensure their customers access fresh milk in convenient locations affordably.

In addition, the KCB Foundation is working with the County Government of Baringo to modernize the Kimalel goat market and animal sourcing systems. The goal is to ensure producers work through cooperatives to deliver animals of the required standards whilst ensuring all health requirements are met. This organization is helping producers to negotiate for better prices. Within the last 1 year, farmers engaged in the programme have been able to sell their animals at a premium and on average they have received 30% higher prices than those not under cooperatives. Livestock keepers are smiling all the way to the bank; for instance during the 2014 annual Kimalel goat auction, cooperatives mobilized their members to deliver 1,580 goats of the required age and weight and they were sold at a value of KES 16 million which went directly to the farmers.

Market access remains a key component of the Mifugo Ni Mali livestock value chain development programme that seeks to commercialise the livestock sector through a pro-poor approach that supports producer organizations into cooperatives, provision of interest free loans to enhance productivity, nutrition, value addition, market access and trade.

KCB Foundation

Appendix 15: Letter of Research Authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@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/15/5572/8124**

Date: **9th November, 2015**

Gideon Muchiri Muriithi
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Impacts of seasonal climate variability and weather forecasts on livestock production and marketing in Baringo County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Baringo County** for a period ending **9th November, 2016.**

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.

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

Copy to:

The County Commissioner
Baringo County.

The County Director of Education
Baringo County.

Appendix 16: Evidence for First Journal Paper Publication

Gmail

gm murithi <murithigm@gmail.com>

---

muri29235.html very urgent

1 message

Reg Preston <reg.preston@gmail.com>
To: gm murithi <murithigm@gmail.com>

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Regards

TRP

Professor T R Preston, PhD, DSc

Investigador Emérito
Centro para la Investigación en Sistemas Sostenibles
de Producción Agropecuaria (CIPAV),
Carrera 25 No 6-62 Cali, Colombia

Senior Editor, Livestock Research for Rural Development
http://www.lrrd.org (The international on-line journal on sustainable livestock-based agriculture)

Tropical Animal Production
http://www.cipav.org.co/TAP/tapindex.htm

Appendix 17: Evidence for Second Journal Paper Publication

Gmail

gm murithi <murithigm@gmail.com>

Manuscript Accepted: 011120172392

2 messages

---

editor@premierpublishers.org <editor@premierpublishers.org> Sat, Dec 9, 2017 at 10:13 PM
To: gm murithi <murithigm@gmail.com>

Premier Publishers
www.premierpublishers.org

Dear Gideon Muriithi,

After a thorough double-blind review, I am pleased to inform you that your revised manuscript entitled " Long-term observed Precipitation Trends in Arid and Semi-arid Lands, Baringo County, Kenya" (011120172392, 1st submission received: November 1, 2017) has been accepted for publication and is scheduled for publication in a forthcoming issue Journal of Agricultural Economics and Rural Development, only if you completely fulfill the following requirements.

Read carefully the Guide for Authors at http://premierpublishers.org/resources/author-guidelines to access the resources you need for preparing the reference styles and the final complete package.
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Appendix 18: Evidence for Third Journal Paper Publication

Gmail

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Manuscript Number: IJRSR-10674/2018

2 messages

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Manuscript Number: IJRSR-10674/2018

ARTICLE TITLE: RELIABILITY OF INDIGENOUS TRADITIONAL KNOWLEDGE AND CONVENTIONAL WEATHER FORECASTSIN THE FACE OF CLIMATE CHANGE AND VARIABILITY IN BARINGO COUNTY, KENYA

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Page count:	132
Word count:	33,374
Character count:	196,394
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UNIVERSITY OF NAIROBI

IMPACTS OF SEASONAL CLIMATE VARIABILITY AND WEATHER FORECASTS ON LIVESTOCK PRODUCTION AND MARKETING IN BARINGO COUNTY, KENYA

Muriithi, Gideon Muchiri
(BSc Agricultural Economics, MA Sociology (Community Development and Project Management)

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN CLIMATE CHANGE AND ADAPTATION, INSTITUTE FOR CLIMATE CHANGE AND ADAPTATION, UNIVERSITY OF NAIROBI.

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