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Sandra AUMA

ASSESSMENT OF THE IMPACTS OF CLIMATE CHANGE ON LIVESTOCK WATER SOURCES AND LIVESTOCK PRODUCTION.

"CASE STUDY, KARAMOJA REGION OF UGANDA''

Defended on 16/11/2021 Before the Following Committee:

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DECLARATION

I, **AUMA Sandra**, master student, registered as PAUWES/2019/MWP02, hereby declare that this thesis is my personal work, completed to the best of my ability without plagiarism. In addition, I declare that all information, material, and results from other works presented here have been properly cited and referenced in accordance with academic rules and ethics.

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SUPERVISOR'S DECLARATION

This research project is submitted for examination with my approval as the University Supervisor.

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RECOMMENDATION

This thesis is the candidate's original work, and it was written with my guidance and assistance. As a result, it is recommended for examination with my approval as the official University Supervisor.

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DEDICATION

I dedicate this thesis to my beloved dad Mr. Otile Milton, my Mum Mrs, Milly Otile for the great support that made this work real. Thanks to my sisters, Christine, Beatrice and my brothers Joshua and Emmanuel for supporting and encouraging me.

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All respondents who sacrificed their valuable time to respond to my questions, my parents; and siblings; you have all been wonderful to me.

May God Bless You All

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LIST OF ACRONYMS

ANOVA	Analysis of variance
CRS	Catholic Relief Services
FAO	Food and Agriculture Organization of the United Nations
F/Y	Financial Year
GDP	Gross Domestic Product
GIS	Geographical Information Systems
IPCC	Intergovernmental Panel on Climate Change
LC1	Local Council One
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MoFPED	Ministry of Finance, Planning and Economic Development
MWE	Ministry of Water and Environment
NDP	National Development Plan
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
OECD	The Organization for Co-operation and Development
SPSS	Statistical Package for Social Sciences
UBOS	Uganda Bureau of Statistics
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WFP	World Food Programme

ABSTRACT

The study examined the impact of climate change on livestock water sources and livestock production using the Karamoja region of Uganda as a case study. The study's objectives were to determine the general public's perception of climate change, to identify the major climatic factors affecting livestock productivity in Karamoja, and to assess the extent to which climate change has affected animal water sources and livestock productivity in the study region. A cross-sectional survey design, as well as a quantitative and qualitative approach, were used in the study. The study population was 258, and the sample size was 222, which was chosen specifically through a purposive and random sampling technique. While the general public was aware of and understands climate change, the study concluded that the likely causes of climate change were numerous, including deforestation, charcoal burning, natural events such as lake currents, carbon emissions, and land degradation. In Karamoja, climate change is causing erratic and uneven rainfall, drying of surface water bodies such as dams and rivers, high temperatures, deforestation, and outbreaks of livestock diseases. It goes on to say that the major climatic factors affecting water sources and livestock productivity in Karamoja are higher temperatures, drying of rivers, dams, and other seasonal surface water sources, decreases in water levels, and heavy rains, floods, and reduced infiltration, and climate change has an 84.7 percent positive impact on water sources for animals and productivity. The following adaptation measures have been proposed: Diversification of livestock and crop varieties, massive tree planting (agroforestry) awareness and sensitization campaigns, increased government and partner investment in water harvesting and agroforestry schemes, and improved capacity of all organizations and institutes involved.

Keywords: climate change, climate change impacts, livestock water sources, livestock productivity, climate change adaptation measures.

CHAPTER ONE

1. GENERAL INTRODUCTION

1.1 Background of the study

This study investigated the impacts of climate change on livestock water sources and livestock production, a case of the Karamoja region of Uganda.

1.1.1. Background of Livestock Production

Livestock production is the world's most important land use, accounting for roughly 45 percent of the planet's land surface (Blake and Nicholson, 2012). Over a billion poor people worldwide depend on livestock farming as their primary source of food and income, with the majority of them living in developing countries (Hurst et al., 2005). People benefit from livestock in a variety of ways, including meat, milk, eggs, hides, feathers, fibers, animal traction, and manure (FAO, 2021). They employ and provide a living for an estimated 1.3 billion people around the world (FAO, 2018). Furthermore, they perform a variety of social, cultural, and financial functions in a wide range of communities (Hurst, Termine, & Karl, 2005; FAO, 2018). Livestock provides insurance, a banking system, status, and income, which are all important in risk management, including climate change risk (Binder, 2019; FAO, 2021). Global production of meat, milk, and eggs has increased rapidly in recent decades in response to rising demand for livestock products. This rise has been fueled by rising populations, rising incomes, and urbanization in developing countries (FAO, 2021). Animal production is becoming increasingly important in the global food supply chain as global demand for animal protein continues to rise as the world population grows (Kebede, 2016).

Although some research suggests that climate change influences livestock productivity (Kebede, 2016; Naqvi, De, Kumar, & Sejian, 2015; FAO, 2018), little is known about how climate change affects livestock productivity. Furthermore, livestock benefits Ugandans in a variety of ways, including income generation and wealth accumulation; the livestock industry provides an income source for approximately 58 percent of Ugandan households, reducing rural poverty; 3.5 percent of total national GDP in the 2018/2019 fiscal year, amounting to more than US $ 1,188

million; and 1-1.5 percent of total export trade value (Waiswa et al., 2021). Despite the above-mentioned contribution of livestock, Uganda faces the challenge of low productivity as a result of climate change (Waiswa et al., 2021).

The Karamoja region in north-eastern Uganda produces roughly 20% of Uganda's livestock (Carabine, E., et al., 2017). The region is known for its heavy reliance on animal husbandry and subsistence agriculture, which is almost entirely dependent on rainfall during the critical rainy season, which occurs each year between March and October and is followed by a long and severe dry season (Carabine, E., et al., 2017). Because of the region's inherent sensitivity to climate conditions and reliance on rainfall, agriculture is one of the most vulnerable sectors to the effects of climate change (WFP, 2016).

According to Rojas-Downing et al., (2017), the most significant factor influencing livestock productivity is unprecedented climate change, which has the potential to affect the quantity and quality of livestock production, as well as the dependability of livestock production and the resources used in livestock production. When the temperature falls below or rises above the normal threshold for optimal animal production, productivity efficiency changes (Baumgard et al., 2012).

1.2. Problem Statement

Livestock production have a long history in the Karamoja region, particularly among those who rely on animal husbandry as their main source of food and income (Carabine, E., et al., 2017; USAID, 2017). According to USAID (2014), households' livestock ownership proportions varied as follows: 40% of the population owned cattle, 49% owned sheep, and 50% owned poultry. People benefit from livestock in a variety of ways, including meat, milk, hides, animal traction, and manure (FAO, 2021). Furthermore, the Karamoja region of northern Uganda produces approximately 20% of Uganda's livestock (Carabine, E., et al., 2017). This helps to create jobs, reduce rural poverty, and contribute to national GDP, which amounts to over $1,188 million, as well as 1-1.5 percent of total export trade value (Waiswa et al., 2021). Despite the above-mentioned contribution of livestock, Uganda faces the challenge of low productivity as a result of climate change (Waiswa et al., 2021).

The livestock production in the Karamoja region is entirely dependent on rainfall during the critical rainy season (Carabine, E., et al., 2017). The region's inherent sensitivity to climate conditions is exacerbated by its reliance on rainfall, making agriculture one of the most vulnerable sectors to the effects of climate change, according to the World Food Programme (2016). More than half of the population is food insecure as a result of unfavorable climatic conditions, with over 12% severely affected (IPCC 2014). Furthermore, in recent years, the environment surrounding livestock rearing has been linked to an increase in the incidence of livestock diseases, an increase in production costs, and a decrease in reproduction rates (Stark, 2011). The aforementioned issues are attributed to unprecedented climate change, which has the potential to impact livestock production quantity and quality, as well as its reliability and the resources used in livestock production (Baumgard et al., 2012). The efficiency of productivity is altered as a result of changing climatic factors when temperatures are either below or above the normal threshold for optimal animal production (Baumgard et al., 2012). Food security and livelihoods are jeopardized as a result of the aforementioned issues, which alter productivity efficiency. As a result, urgent policy attention is required. Against this backdrop, a case study of the Karamoja region of Uganda was conducted using primary data from the region to assess the effects of climate change on livestock water sources and livestock productivity.

1.3. Objectives

1.3.1. Main Objective

The overall objective of this study is to assess the impacts of climate change on livestock water sources and livestock productivity, a case study of Karamoja region of Uganda.

1.3.2 Specific Objectives

To achieve the main objective, the following were the specific objectives of the study.

- To find out the perception of the public on climate change
- To ascertain the major climatic factors affecting productivity of livestock in Karamoja
- To assess the extent to which climate change has affected water sources for animals and productivity of livestock in the study region

1.3.3. Research Questions

To achieve the above desired objectives, the following questions were asked; -

- What is the perception of the public on climate change?
- What major climatic factors affect livestock productivity in Karamoja region?
- To what extent has climate change affected water sources for animals and productivity of livestock in the Karamoja region?

1.4. Justification and Significance of the Study

Many parts of the world are already feeling the effects of climate change. Rising sea levels, rising temperatures, and erratic weather patterns have all been blamed. Droughts, heat waves, storms, desertification, and insect infestations are among the weather-related disasters and extreme weather events that are expected to increase as a result of climate change (Baumgard et al., 2012). Long-term climate change will have an impact on water availability, potentially jeopardizing its supply as well as the future of all animals.

Agriculture, particularly livestock farming, is the mainstay of Uganda's Karamoja region households. Putting people's primary source of income at risk will have a negative economic impact. Because there are still considerable gaps in knowledge concerning climate change adaptation and mitigation, the goal of this research is to provide solutions by making recommendations on adaptation measures to impending climate change shocks. This will not only benefit the research or area under investigation, but also all regions that are impacted on by climate change. Since climate change impacts not only people’s source of income, which is livestock production but also could lead to food insecurity inadvertently, the adaptation measures must therefore be implemented to avoid needless risks.

1.5. Scope of the Study

This study was conducted in the Ugandan district of Karamoja, which is located in the country's north-eastern region, specifically in the districts of Napak, Moroto, and Nakapiripirit. It is a semi-arid region bordered to the north by South Sudan and to the east by Kenya. According to

the World Food Programme (2016), Karamoja is Uganda's poorest region, with a population of over 1.2 million people who rely on animal husbandry and subsistence agriculture, which is almost entirely dependent on rainfall during the critical rainy season. As a result, the research concentrated on the effects of climate change on livestock water sources and livestock production.

1.6. Limitations

Lockdown restrictions in the country due to Covid-19, prohibition on public transportation and limited number of passengers allowed in private vehicles all interrupted early data collection which was scheduled for July, 2021 as per the work plan, and so the researcher had to reschedule the timing to August, 2021. In this regard, there was limited time available since the researcher had to meet deadlines for submission of the draft report. Also, to overcome transportation issues, the researcher had to hire a private car from a car hire service company for easy movements during data collection.

Communication barrier: Most of the data collection was done in rural communities, so language barrier was a huge problem since majority of the respondents in the rural areas do not comprehend English. Additionally, there are many tribes in Uganda with discrete languages which the researcher is not conversant with. To overcome this challenge, the researcher hired a local translator who was a native of the region and knew the local language of the region. He translated the language during the whole phase of data collection, especially during focus group discussion and while administering questionnaires.

The researcher faced another challenge of long distances traveled to locate the respondents in the regions. Besides the distance, homesteads were scattered, while other areas were hard to reach areas with poor road networks, not easily accessed, especially in Napak and Nakapiripirit districts of Karamoja.

Financial constraints; the half grant that was given to the researcher was insufficient and not enough to cover most of the expenses. Considering the fact that the research was more dependent on primary data, the surveys required the largest share of the budget. Also, Covid-19 impacts had made everything in the country so expensive which resulted in increased expenditures. To overcome this problem, the researcher had to improvise funds from stipends and other sources.

Tribal and inter-communal conflicts; Karamoja region is an area that is well known for having conflicts caused mainly by cattle rustling amongst neighboring communities and other tribes. Although this was an indirect effect, it affected data collection since the researcher could not reach some potential areas with useful respondents to the surveys and research.

1.7 Structure of the Research

This section gives a brief explanation of the research outline. Chapter one includes a brief explanation of the research background, problem statement, research objectives, research questions, justification/significance as well as scope and limitations of the study. Chapter two constitutes a literature review, and accordingly, contains viewpoints of other authors regarding the research area in general. Chapter three addresses methodology. It contains explanation of research design, sample size determination, and data collection methods. Sampling and data analysis aspects of the study are also included in this chapter. Chapter four constitutes results and discussions of the analyses carried out. It contains presentations of the primary data collected through questionnaires, interviews and focus groups discussions. Presentations of primary data findings have been facilitated through tables, bar charts and pie charts. Brief discussions have been included to explain each table and chart. The chapter also plays an important role in the achievement of research aim and objectives, and in-depth discussions have been provided in relation to each individual research objective. Chapter five concludes and recommends the work. It provides solutions to impending climate change shocks and highlights scope for future studies in the same research area.

CHAPTER TWO: LITERATURE REVIEW

2.0. Introduction

This chapter discusses the review of available literature by scholars and academicians that was used in this study.

2.1. Climate Change

Climate is a set of weather conditions that prevail in an area over a long period of time (FAO, 2021). Several factors define climate, including long-term average temperature and precipitation, as well as the type, frequency, duration, and intensity of weather events such as heatwaves, cold spells, storms, floods, and droughts (FAO, 2018). The Intergovernmental Panel on Climate Change's evidence is now overwhelmingly conclusive that climate change is occurring (FAO, 2021).

In contrast to the rest of Uganda, which has two distinct rainy seasons, Karamoja traditionally has a single long rainy season that lasts from April to November. Rainfall is at its highest in April and May, with a brief respite in June. The rains return in July or August and continue until November (Carabine, E., et al., 2017). In Abim and Nakapiripirit, the annual average rainfall ranges from 300 mm in the pastoral areas to 1200 mm in the western areas **(figure 1a).** The region's average annual temperature ranges from 16°C in the highlands to 24°C elsewhere **(figure 1b).** (USAID, 2017). Previous research has found that warmer regions in Uganda have expanded over the last 60 years, negatively impacting the Karamoja region during critical times of the year, with an increase in average temperature of 1.3°C. It was stated that there was an increase in temperature for both minimum (0.9°C) and maximum (1.6°C) during the period (1975–2009), as well as a 20–28 percent increase in the average number of days with extreme heat ("hot" days) between 1960 and 2003, with especially significant increases between June and August (Carabine, E., et al., 2017; FAO,2021). Furthermore, the rainy season has become less reliable, with earlier cessation in Kotido and Kaabong, and earlier onset/later cessation in Napak and Abim (the latter implying an expansion of the growing season) and a 15–20 percent reduction in total annual rainfall. with a shorter rainy season, increased June rainfall, and decreased September–October

rainfall (FAO, 2021). Also, the graphical representation shown below depicts the historical rainfall trend of the Karamoja sub-region for the period of 1980 to 2009 (Egeru et al., 2019)

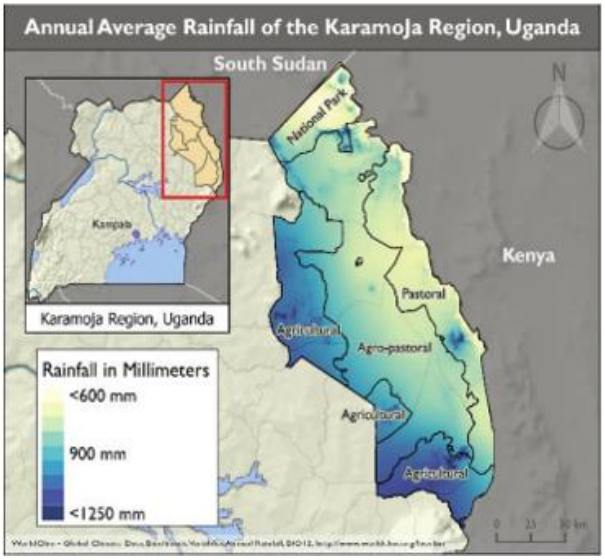


Figure 1a: Average Rainfall in Karamoja, 1881-2000

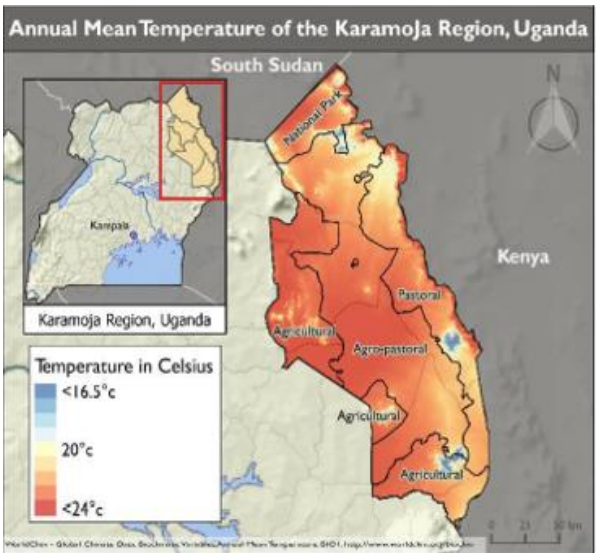


Figure1b: Mean Temperature in Karamoja, 1881-2000

Source: Adapted from USAID, (2017). Climate Risk Screening for Food Security Karamoja Region, Uganda.

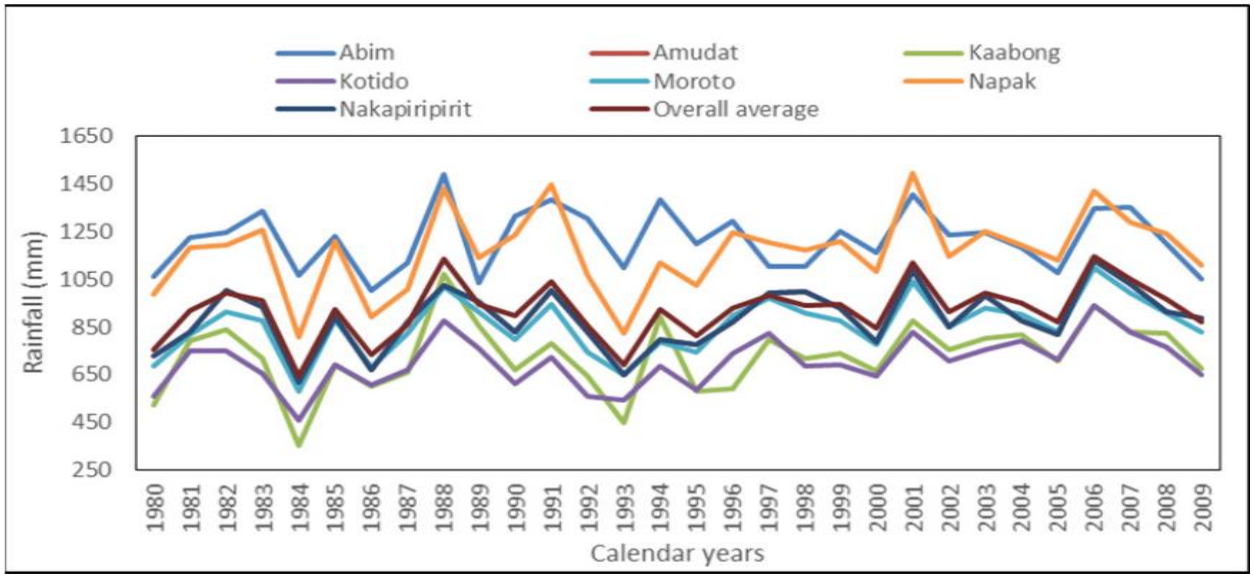


Figure 2: Historical Rainfall Trend of the Karamoja Region (1980-2009)

Source: Adapted from Egeru et al., (2019). Past, present and future climate trends under varied representative concentration pathways for a sub-humid region in Uganda.

2.2. Water Sources and Water for Livestock

Water scarcity in the Karamoja Region is being blamed on climate change. Over a 60-year period, an examination of changes in rainfall patterns in the region under investigation reveals: (a) "Decreased reliability of rainy season – with early cessation in some parts, and earlier onset/later cessation in other regions." (b) "A reduction of 15–20 percent in total annual rainfall, with a shorter rainy season." (c) An increase in June precipitation combined with a decrease in September–October precipitation (USAID, 2017). For livestock water sources, Mugerwa et al. (2014) classified water for livestock farmers in Karamoja based on major water sources (ponds, windmills, and bore holes), which were the main sources used by small goat, sheep, and donkey herders. Valley tanks, dams, and river beds are another type of water source used by larger livestock herders. However, some of the region's bodies of water are drying up, making livestock feeding more difficult. As a result, herders must travel long distances to find water for their animals.

The consequences of climate change include extremely high and hot temperatures, which reduces rainfall expectations and has a negative impact on rangeland yields. Degradation is the end result of such changes, which has a negative impact on livestock production and lowers yield levels. It is predicted that Sub–Saharan Africa will experience adverse weather, high levels of flooding, and all of these will impact negatively on livestock production in a very short period of time, actually a few years from now, as a result of these adverse weather occurrences (Kebede, 2016).

Livestock is estimated to occupy approximately 30% of the world's surface free land on average. As a result, approximately 16.7 percent of the world's estimated population of 7.8 billion people work in livestock production. As a result, livestock production is critical to human survival, and any attempt by climate change to reduce its productivity will have disastrous consequences for the survival of the human race (Kebede, 2016).

Global livestock production shortfalls have been blamed on climate variability and extreme weather events, as well as inefficient and ineffective animal husbandry. Many studies in this field have revealed a number of climate change-related issues affecting livestock production. As a result, it has been discovered that climatic conditions such as humidity, temperature, wind speed,

and precipitation typically influence livestock growth, weight, milk and wool production, and reproduction (OECD, 2014).

As a result, the purpose of this study was to assess and investigate how climatic factors have either directly or indirectly affected the components of livestock productivity in Uganda's Karamoja Subregion, in order to find solutions to avoid such unprecedented conditions that have a negative impact on livestock productivity.

2.3. Climate Change and its impact on Livestock Water Sources

Climate change is expected to cause a shortage of drinking water for billions of people, including livestock, in the coming years, particularly in developing countries. As a result, the world's population must collaborate to devise methods and means of adapting to and controlling the effects of climate change (United Nations Framework Convention on Climate Change, 2007). It is estimated that 1 to 2 billion people worldwide suffer from a scarcity of water resources, equating to nearly 30% of the total 12 billion livestock population that lacks drinking water. According to the projections above, climate change will cause a significant lack of water, affecting global livestock production in the coming decades (Calvosa, Chulunbaatar, & Fara, 2009)

Precipitation is expected to increase significantly in most parts of the world as a result of changes in weather patterns. This is expected to occur in areas with very high and mid latitudes, whereas low latitudes and tropical savannah grass land in general are expected to receive less rainfall. As a result, areas in high latitudes will experience excessive rainfall, while areas in low latitudes will experience continuous dry spells, both of which are detrimental to livestock production. This will undoubtedly affect the hydrological dynamics of livestock-specific water compartments such as lakes, underground water, and rivers (OECD, 2014).

Water availability determines the best pasture for livestock production, as determined by its quality. It should be noted that pasture is the best source of animal (livestock) feed; however, when weather conditions such as high temperatures occur, resulting in reduced water levels due to evaporation, animal reproduction rate in terms of growth may be affected (OECD, 2014)

As a result, the study seeks to investigate the impact that climate change has had and will continue to have on the various water sources in the Karamoja Sub Region, which will affect livestock production. Given that water is a critical resource in livestock production and/or productivity and that livestock production is the primary agricultural activity in the Karamoja Sub Region, it is prudent to provide better solutions for the upkeep of the various water sources on which the Karamoja Sub Region depends for livestock productivity.

2.4. Climate Change and Productivity of Livestock

Climate change is wreaking havoc on all agricultural sectors worldwide, including crop and livestock farmers. Heat stress is the most important climatic factor affecting productivity, according to Chauhan and Ghosh (2014)'s study of the contribution of ruminant livestock to climate change as a result of enteric methane emission, and the resulting effects on livestock productivity in India. This stress, they claim, reduces the economic benefits of raising high-yielding dairy cattle. Temperature and rainfall variations, according to Baumgard et al. (2012), are the most influential climatic factors influencing livestock disease outbreaks. Higher temperatures, as well as erratic rainfall patterns, have a significant impact on disease pathogenic bacteria, viruses, parasites, and fungi survival in livestock. According to Wall and Ellse (2011), insects that transmit disease agents, such as mosquitoes and ticks, may benefit from climate change. They claimed that a warmer climate would increase parasite abundance and disease incidence, negatively impacting livestock.

Kathlee and Mary (2017) recently explained the temperature variation in Karamoja over a 35-year period (**Figure 3**). This revealed that average monthly temperatures in the Karamoja region are rising, affecting livestock forage quality and resulting in lower livestock productivity. Furthermore, Baumgard et al. (2012) demonstrated how climate variability affects animal feeding habits, affecting their growth and overall productivity (**Figure 4**)

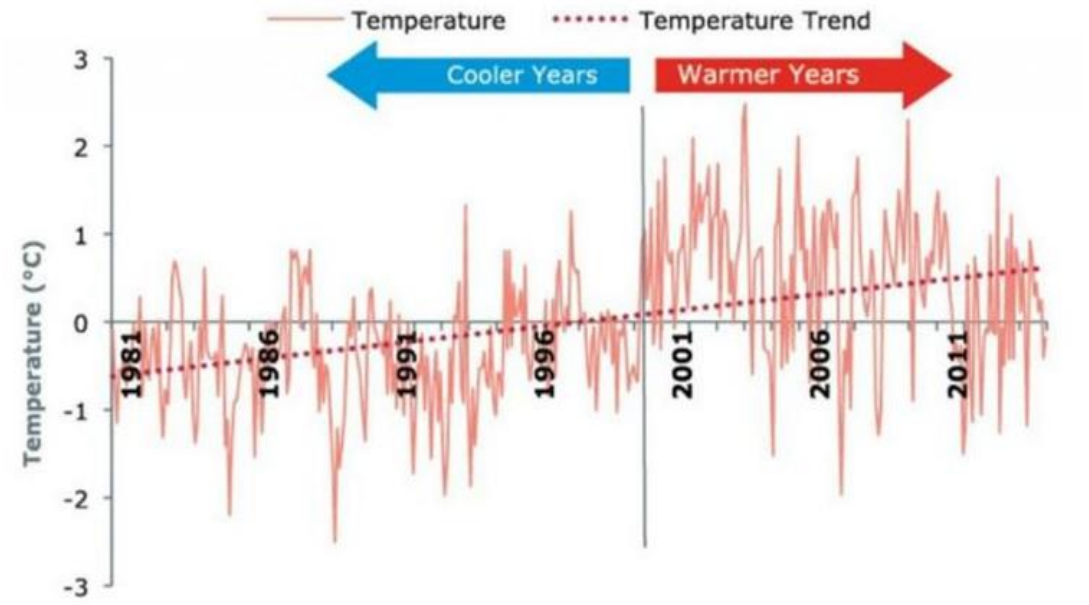


Figure 3: Variation in temperature in Karamoja over a 35-year period

Source: Adapted from Kathlee and Mary (2017). The Impacts of Climate Change on Food Security and Livelihoods in Karamoja.

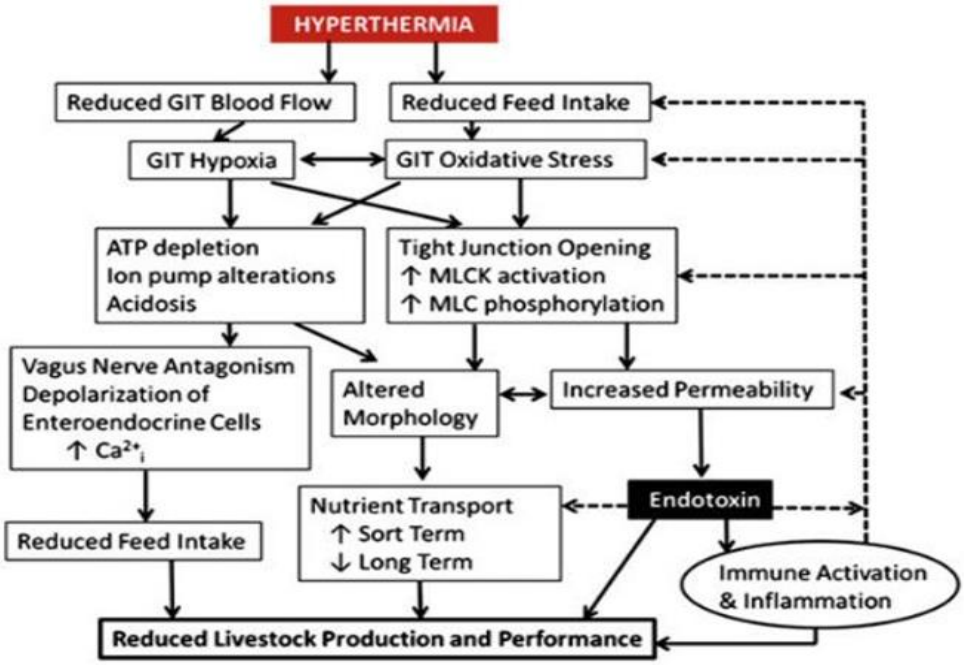


Figure 4: Impact of climate on Livestock Production

Source : Adapted from Baumgard et al. (2012). Impact of Climate Change on Livestock Production.

2.5. Summary of the Literature Review

Some researchers conducted studies on the effect of water resources on livestock in Karamoja (Mugerwa et al., 2014); climate risk management for smallholder farmers (Shikuku et al., 2017); and the effect of climate change on livestock production (UNFCCC, 2012; Chauhan, 2014) for the area under investigation.

The research gap was that (Chauhan, 2014) took a comprehensive approach. Our study will rely on up-to-date data and real-life experiences of specific Karamoja residents that will be relevant to the water policy field because a major effect of climate change is felt directly in water supply and availability, which will have a direct impact on livestock production. Furthermore, one of the goals of this research is to propose adaptation measures to help mitigate the inherent effects of climate change on water supply. In addition, policy measures will be recommended that will assist livestock farmers in coping with climate change shocks to a large extent without jeopardizing their primary source of income.

CHAPTER THREE: MATERIALS AND METHODS

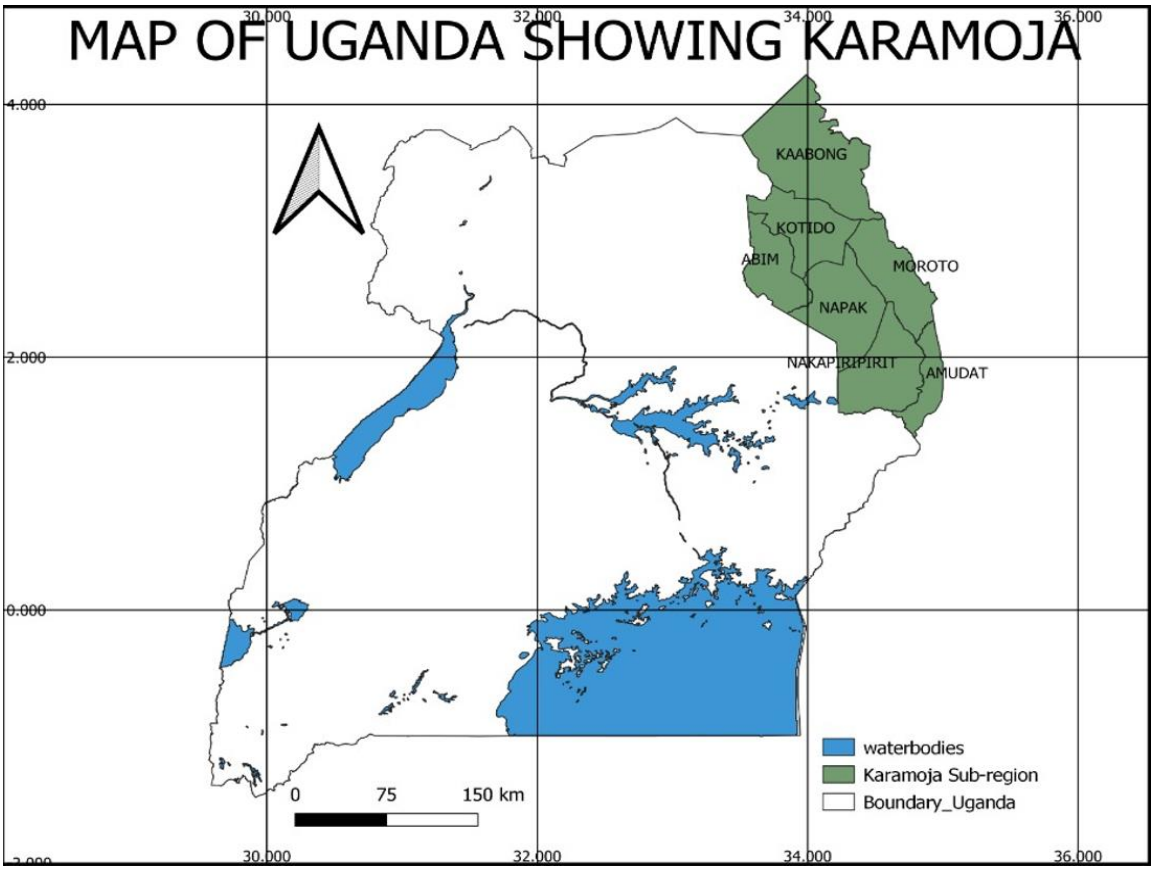
3.0. Introduction

This chapter describes the study's area, the materials used, and the procedures used to determine sample size, data collection methods, and analysis tools used to obtain the results.

3.1. Study Area

3.1.1. Location

Karamoja, the specific area of this study, is located in northeastern Uganda **(Figure 5).** It covers an estimated area of over 27,200km^2 (NEMA, 2010). It is a semi-arid region which is on the borders of South Sudan to the north and Kenya to the east. According to the WFP (2016), Karamoja is home to the most impoverished region of Uganda, and with a population of over 1.2 million people (UN Women Watch, 2017), having the poorest development indicators.



Source: Researcher's GIS snapshot, 2021

Figure 5: Map of Uganda showing Karamoja

3.1.2. Socioeconomic Situation

The Karamojong are known for their reliance on animal husbandry and subsistence agriculture, which is almost entirely dependent on rainfall during the critical rainy season, which occurs annually between March and October and is followed by a prolonged and severe dry season. The region's inherent sensitivity to climate conditions is increased by its reliance on rainfall, making agriculture one of the most vulnerable sectors to the effects of climate change, World Food Programme (2016). Due to unfavorable climatic conditions, more than half of the population is food insecure, with over 12% severely affected (IPCC 2014). Furthermore, the region's lowest human development index has been attributed to socioeconomic challenges such as poverty and vulnerability. According to UBOS (2019), 74 percent of the Karamojong live in extreme poverty.

3.1.3. Livelihood zones of Karamoja Region

There are three types of livelihoods in the Karamoja region **(Figure 6),** which runs from north to south and has varying climatic conditions. These livelihood types are adapted to the climate of their respective regions. According to USAID (2017), the climate risk screening for food security in Uganda's Karamoja region is classified as follows:

Pastoral Area: This region is semi-arid, with long dry seasons and erratic rainfall. Livestock production (cattle, goats, and sheep) is the main source of income, with selective crop cultivation in years with adequate rainfall. The average annual rainfall is less than 300–500 mm.

The agro-pastoral region is less dry, with 500–800 mm of annual rainfall distributed erratically. The sandy-loamy soils of this region support crops such as sorghum, millet, maize, beans, cowpeas, and groundnuts. Steers, bulls, sheep, and goats from transhumant herds are the mainstays of livestock production.

The agricultural zone is the wet Karamoja zone, which has fertile loamy soil. The annual rainfall in this area ranges from 800 to 1200 mm. This zone is ideal for a wide variety of crops and can frequently accommodate a second and third planting of quick-maturing cash and food crops. The United States Agency for International Development (USAID) (2017)

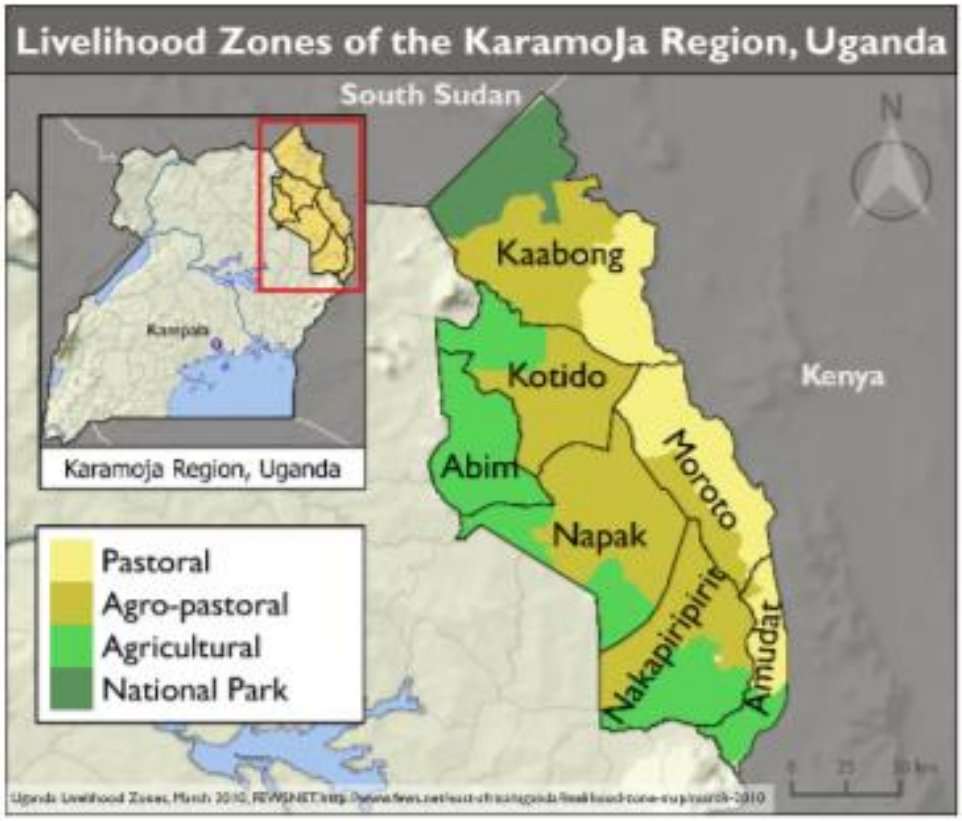


Figure 6: Livelihood Zones of Karamoja Region

Source: Adapted from USAID, (2017). Climate Risk Screening for Food Security Karamoja Region, Uganda

3.2 Research Design

The researcher used a cross-sectional survey design. Cross-sectional studies take place at a single point in time or over a short period of time (Amin, 2005). A combination of quantitative and qualitative methods was used. When one approach is insufficient to reveal all that is to be known about a phenomenon, a combination of qualitative and quantitative design strategies is used. The quantitative approach was used to analyze primary data from the field using descriptive statistics, whereas the qualitative approach was used to describe occurrences and discussions in relation to the results of the interviews and focus group discussions. The quantitative findings on the study variables were supplemented by qualitative information.

3.3 Sample Size Determination

Karamoja is divided into seven districts, with a total population of approximately 1.2 million people. However, a total of 258 respondents from three districts (Napak, Moroto, and Nakapiripirit) were studied, with a sample size of 222. The respondents were evaluated using the R.V. Krejcie and D.W. Morgan (1970) table, which is defined as a table for determining sample size for research activities. The sample size determination table is detailed below; -

Table 3.1: Target Population and Sample Sizes per District.

S/no	Categories	Target Population	Sample Size	Sampling Technique
A. Questionnaires				
1.	Napak	75	63	Random Sampling
2.	Moroto	70	59	Random Sampling
3.	Nakapiripirit	75	63	Random Sampling
	Sub Total	220	185	
B. Interviews				
1.	Napak	10	10	Purposive Sampling
2.	Moroto	15	14	Purposive Sampling
3.	Nakapiripirit	10	10	Purposive Sampling
	Sub Total	35	34	
C. Focus group discussions				
1.	Napak	1	1	Purposive Sampling
2.	Moroto	1	1	Purposive Sampling
3.	Nakapiripirit	1	1	Purposive Sampling
	Sub Total	3	3	
	Total	**258**	**222**	

Source: Primary Data

The researcher used both purposeful and simple random sampling techniques. Purposive sampling was used to find respondents with similar characteristics. This allowed for the gathering of specific units or cases based on a specific goal. Simple random sampling is a method of selecting

respondents in which each respondent has an equal chance of being chosen for a sample. The method is unbiased and results can be generalized.

3.4 Data Source:

Data was gathered in both quantitative and qualitative formats. Quantitative data were collected using questionnaires from four sub-counties of Moroto District: Nadunget, Northern Division, Southern Division, and Rupa sub-county; two sub-counties of Napak District: Matany and Ngoleriet; and from three sub-counties of Nakapiripirit District: Lorengedwat, Nabilatuk, and the Nakapiripirit Town Council. Qualitative data was collected using interviews and focus group discussions.

Local Elders (Ikasuko), Local council leaders, Agricultural Extension workers at Local Government Offices of Moroto, Napak and Nakapiripirit, Water Officers in Ministry of Water and Environment as well as those working in NGOs (Welthungerhilfe and CRS), Livestock Production Officers of Agricultural Institutes, Chairpersons of the water user committees, Livestock local and seasoned Herders, Farmers, Community Organizers, and others contributed to qualitative data.

3.5 Data Collection Methods:

This research was divided into two sections. The first section included a thorough review of the literature. The literature review was conducted as a desk review using keywords gleaned from the internet. The documents found were filtered based on their publication date, study location, and topic relevance. The goal was to thoroughly discuss all major issues affecting the research. A list of secondary data sources was also used and analyzed to obtain information on climate change, water sources, and livestock productivity in the study region.

The gathering and analysis of primary data was the focus of the second stage. The researcher used questionnaires, interviews, and focus group discussions to collect primary data. Each method is explained in depth below.

A questionnaire approach was used to collect data over a large area in a short period of time. This is because it is standardized to prevent response falsification. The questionnaire was brief, descriptive, and straightforward.

To collect qualitative data, a semi-structured interviewing methodology was used. The method was used to collect confidential study data that would be impossible to obtain through a questionnaire. The method was used to collect qualitative data that could not be collected with any other tool, and it was intended to aid in the collection of more accurate information about the sample. It was time consuming, however, because information was gathered from highly qualified respondents, and it required more resources to complete because schedules, meetings, and other events were constantly fixed and rescheduled.

Focus group discussions were also used, with elders (referred to as Ikasuko) and youths (referred to as Karachunas) participating to identify some of the challenges of livestock water sources in the study districts, as well as how livestock productivity has decreased or increased over time. Elders, local leaders, and seasoned herders were approached in the region for their perspectives on climate change and actual livestock and herder movements for water, particularly during peak water scarcity periods.

3.6. Data analysis

The questionnaires were collected, sorted, and coded before entering them into SPSS 26 for Windows, which is a statistical package that was used to generate ANOVA, mean, standard deviation and regression. Statistical summaries of the results were displayed in tables of frequencies and percentages, as well as other relevant software, to aid in interpretation. Also, tables for mean, for standard deviation and pie charts were generated from SPSS version 26 to aid interpretation. The information gleaned from interviews and focus group discussions was presented and analyzed qualitatively through a thematic analysis technique by assigning codes to create meaningful themes.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction

The chapter deals with the results of a cross-sectional survey design (snapshot of events as they existed at that particular point in time) as pointed out in the methodology.

4.1 Demographic characteristics of the respondents

This part presents the demographic characteristics of the study population. The responses were analyzed using descriptive and inferential statistics as presented in table 4.1.

Table 4.1: Demographic Characteristics of the respondents

Items	Response	Frequency	%
Gender	Male	99	53.5
	Female	86	46.5
Age bracket	18 – 25	28	15.1
	26 – 35	58	31.4
	36 – 44	50	27.0
	45 – 53	19	10.3
	54 – 62	14	7.6
	63^{+}	16	8.6
District	Napak	60	32.4
	Moroto	65	35.1
	Nakapiripirit	60	32.4
Years Lived	Less than 1 year	1	0.5
	1-5 years	13	7.0
	6-10 years	29	15.7
	11-15 years	36	19.5
	16 and above	106	57.3
Education	No Formal Education	52	28.1
	Primary	22	11.9
	UCE	30	16.2
	UACE	31	16.8
	Bachelor	38	20.5
	Master	3	1.6
	Others	9	4.9
Employment	Government Employee	16	8.6
	Religious Institution	4	2.2
	Small business-personal	22	11.9
	Small business-for another	14	7.6
	NGO worker	34	18.4
	Retired civil servant	7	3.8
	Student	29	15.7
	Housewife	11	5.9
	Unemployed	2	1.1
	Farmer/ Herder	46	24.9

N= 185

According to the data in table 4.1, describing the demographic characteristics of the respondents, the male respondents dominated the study (99 persons represented 53.5 %), while female respondents were 86 persons and represented 46.5 %, implying that male respondents influenced the findings. This is represented in figure 7 below.

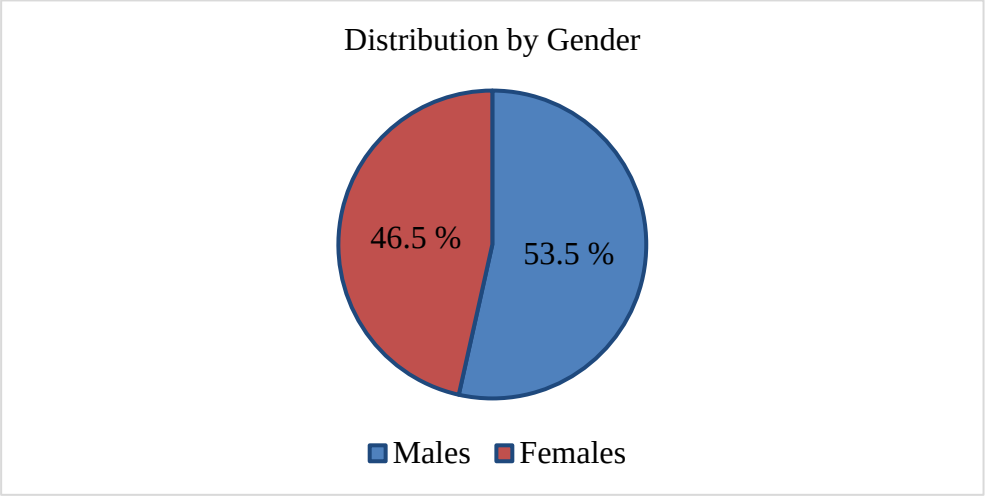


Figure 7: Distribution by Gender

Table 4.1 also revealed that the majority of respondents, 58 (31.4 %) and 50 (27 %), were between the ages of (26-35) and (36-44) respectively, which implied that they were mature enough to provide positive information as they were considered knowledgeable on the subject matter of study. This is represented in the figure 8 below.

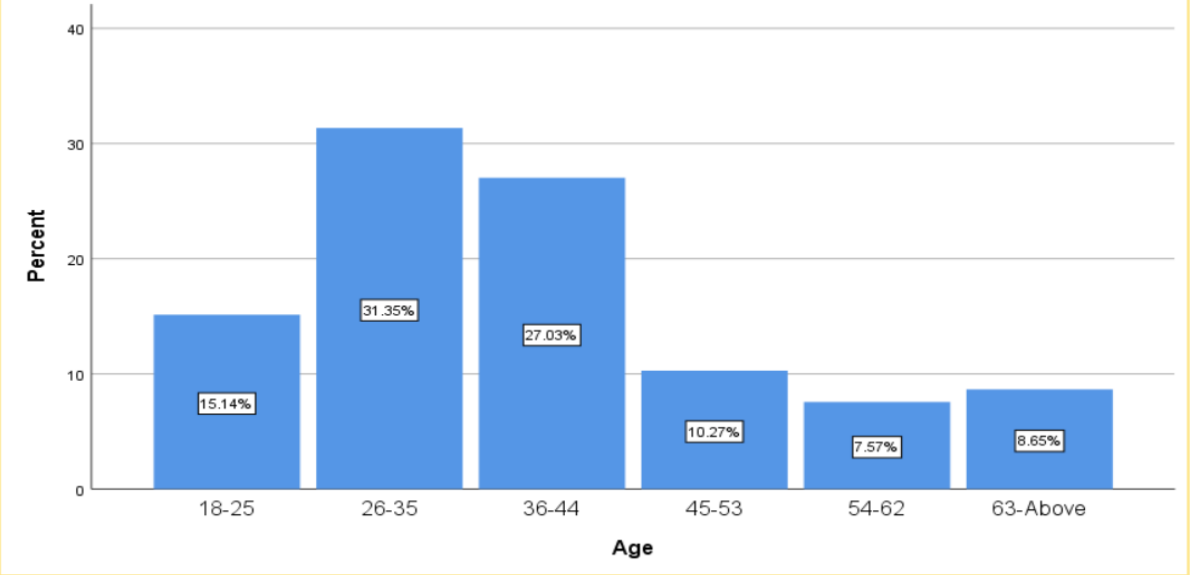


Figure 8: Distribution by Age

With regard to the respondents by district, the findings reveal that 60 persons (32.4 %), 65 persons (35.1%) and 60 persons (32.4 %) of the respondents were from Napak, Moroto and Nakapiripirit, respectively. This implied that respondents were representatively selected from the districts of the study. (Figure 9)

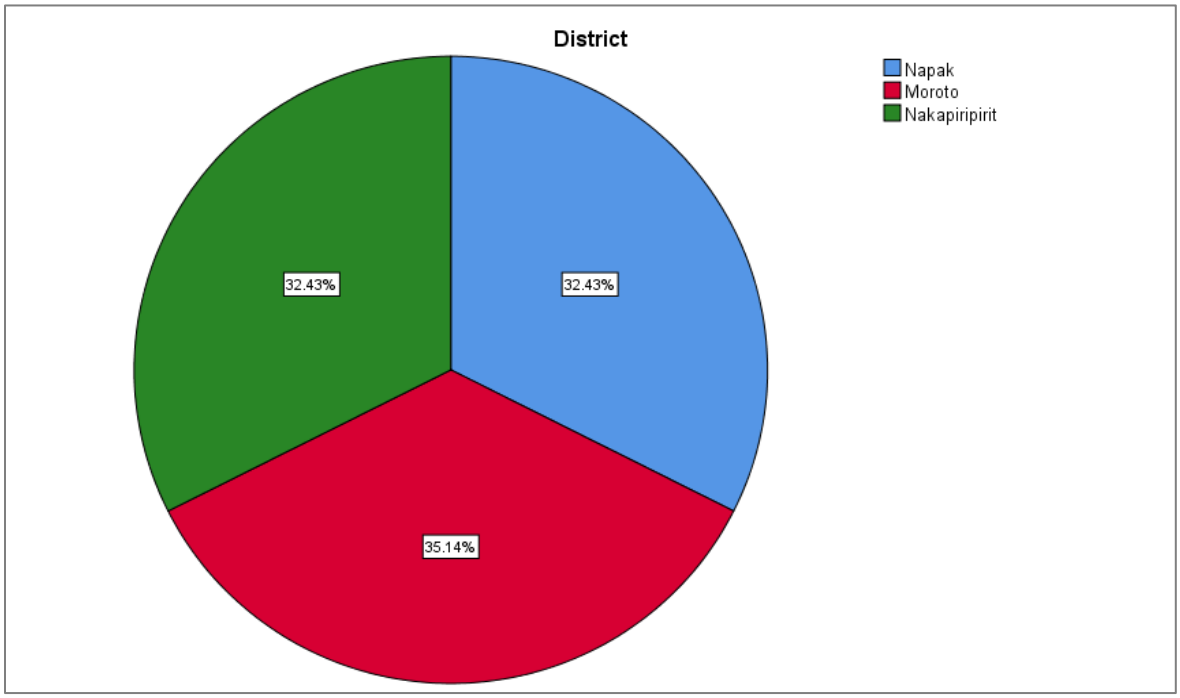


Figure 9: Distribution by District

Majority 106 persons (57.3 %) of the respondents had lived in the area for a period of sixteen (16) and over years with good experience on the impacts of climate change on livestock water sources and livestock production. (Figure 10)

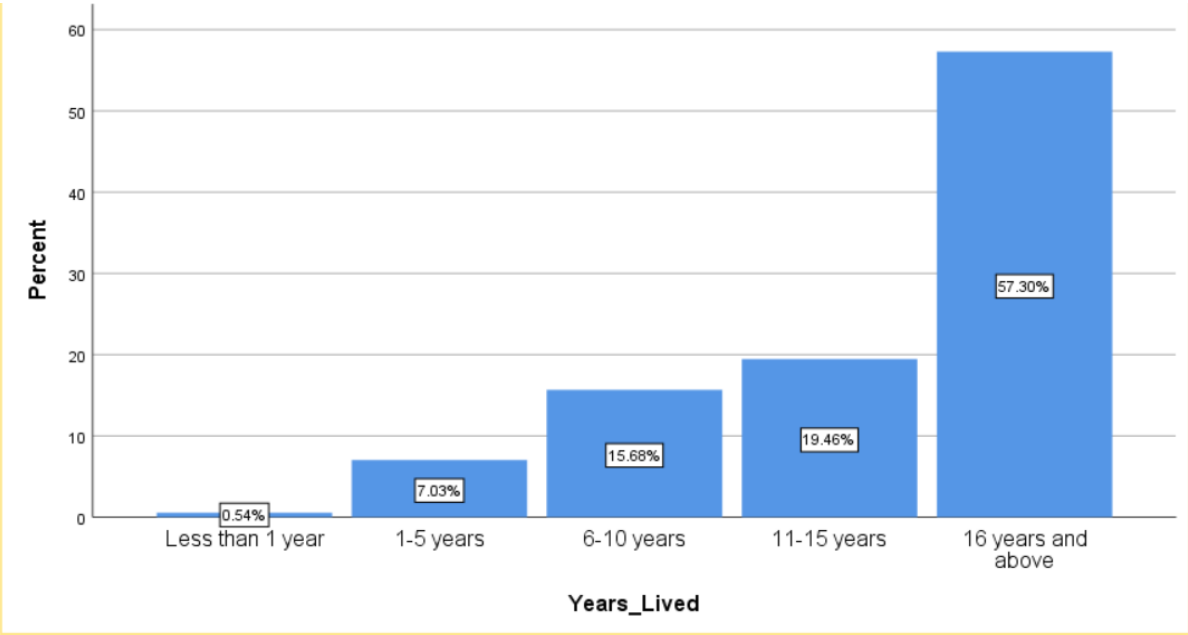


Figure 10: Distribution by Years lived

Furthermore, with regard to education, respondents had a minimum level of education of UCE (16.2 %), UACE (16.8 %), bachelor (20.5 %), masters (1.6 %), and certificate and diplomas (4.9 %). Meaning they could easily understand and had knowledge in the subject matter of study. (Figure 11)

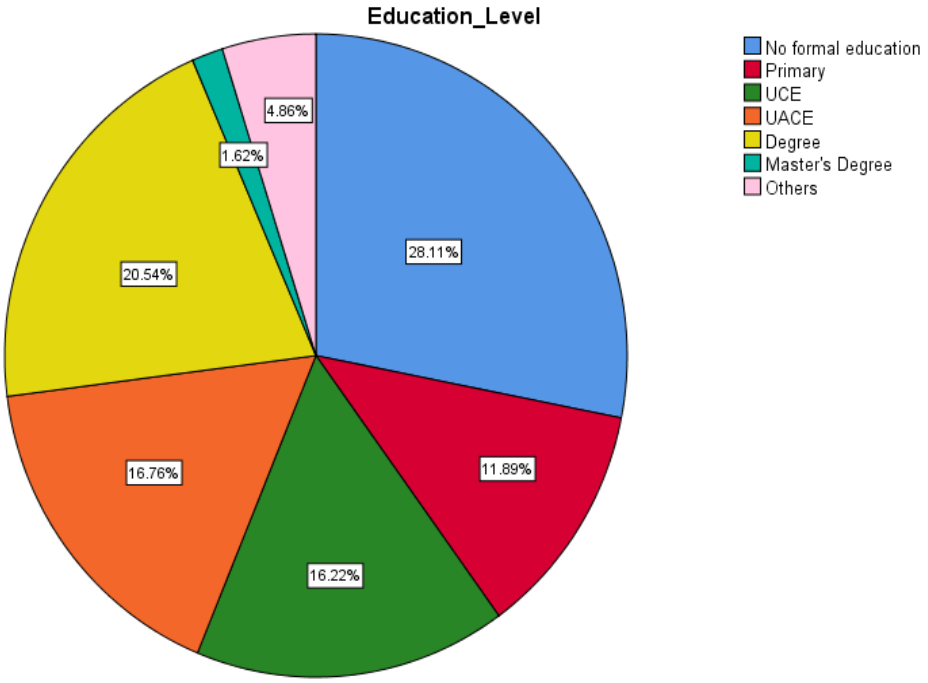


Figure 11: Distribution by Education Level

Moreover, respondents were employed in various disciplines, government employee (8.6 %), religious leaders (2.2 %), business owners (11.9 %), operators of other peoples' businesses (7.6 %), NGO workers (18.4 %), and retired civil servant (3.8 %); Figure 12.

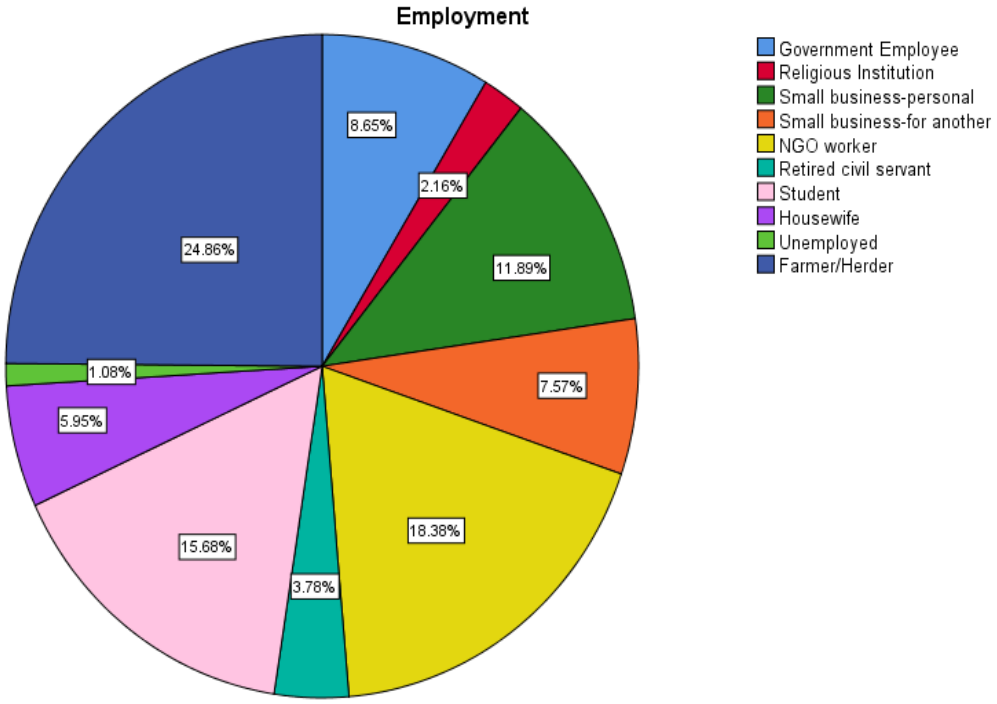


Figure 12: Distribution by Employment

In terms of interviews, there were 15, 10, 10 respondents from Moroto, Napak, and Nakapiripirit districts interviewed respectively, implying that respondents were drawn from all districts. The study also revealed that interviewed respondents ranged in age from 24 to 59 years old, 18 to 29, and 21 to 62 years old respectively, from the districts of Moroto, Napak, and Nakapiripirit, respectively. This implying that they were knowledgeable about the effects of climate change on livestock water sources and livestock production. In terms of the number of years lived by the interviewed respondents, the study revealed that they had lived in the districts of Moroto, Napak, and Nakapiripirit for a total of 6–59, 6–21, and 15–62 years, respectively.

4.2 Perception of the Public on Climate Change

This part presents the publics' perception on climate change of the study population. The responses were analyzed using descriptive and inferential statistics as presented in table 4.2.

Table 4.2: Perception of the Public on Climate Change

Items	Response	Frequency	Percent
Have you ever heard about climate change?	Yes	172	93.0
	No	13	7.0
Do you understand what climate change is	Yes	154	83.2
	To some extent	31	16.8
	No	0	00.0

N= 185

According to the results from Table 4.2, the majority of respondents 172 (93.0 %) have ever heard about climate change, 154 (83.2 %) understand what climate change is, 31 (16.8 %) understand what climate change is to some extent, and none said they did not understand what climate change is. This was confirmed by their definition of climate change as a change in temperature and rainfall patterns in a region over a long period of time, or changes in climate recorded over a long period of time. Furthermore, climate change was defined in the focused group discussion as a change in the earth's climate caused by either human activities or natural processes that are already occurring or predicted to occur. For example, changes in air and surface water temperatures, changing rainfall patterns, surface water rises, changes in the frequency and intensity of extreme events such as droughts and floods, as well as changes in the amount of rainfall, temperature, humidity, and other weather elements evidenced by droughts, floods in a location after a long time period. The definition of climate according to the study is in agreement to that of FAO (2018) that climate is the set of weather conditions that prevail in an area over a long period of time and climate change as long-term average temperature and precipitation, as well as the type, frequency, duration and intensity of weather events such as heat waves, cold spells, storms, floods and droughts.

As a result, they were able to express their opinions on the likely causes of climate change, as depicted in the pie chart in Fig 13 below:

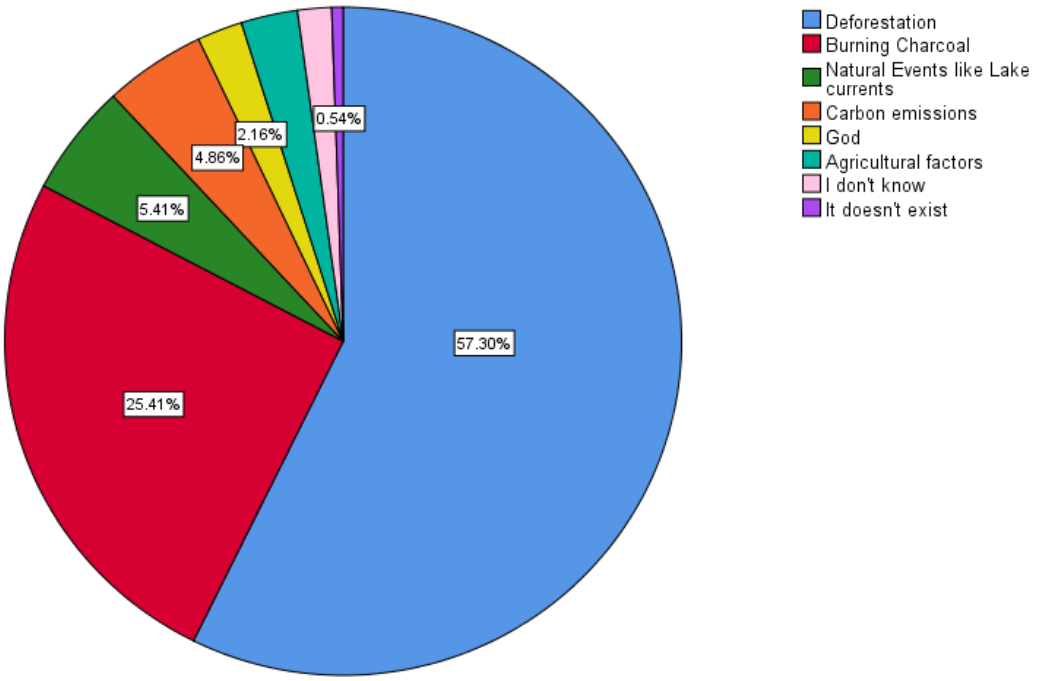


Fig 13: Respondents' opinion for causes of climate change

According to the findings presented in the pie chart above, the likely causes of climate change are numerous, with 57.30 % of respondents believing that deforestation is the likely cause, 25.41 % believing in burning charcoal, 5.41 % believing in natural events such as lake currents, and 4.86 % believing in carbon emissions from vehicles and industries/factories to be the causes. The interview also confirmed that the primary causes of climate change in Karamoja were deforestation, human activities such as bush burning, natural effects, and the use of fossil fuels such as oil and coal.

According to a focused group discussion, the following were the major causes of climate change in the Karamoja region:

a) Deforestation; the respondents believed that forest exploitation has been a contributor to climate change. Trees help to regulate the climate by absorbing CO_2 from the atmosphere, but when they are cut down, the stored carbon is released into the atmosphere, leading to carbon dioxide build up in the atmosphere.

b) Human activities such as the use of fossil fuel was considered as the other cause of climate change. People have been burning an increasing amount of fossil fuels, and as a result, carbon dioxide has led to "greenhouse effect" that has warmed the region.

c) Transportation and urbanization are all factors to consider. Toxic fumes are released into the atmosphere as a result of vehicle emissions, which contributes to global warming.

d) Nitrous oxide emissions released through intensive farming/agricultural activities, as well as use of pesticides and fertilizers in agricultural applications have also contributed to climate change and global warming.

e) Increased livestock farming; the respondents related this in terms of animal feeds. When cattle and sheep digest their food, they emit a lot of methane, which is a greenhouse gas.

f) Land degradation; this has as well contributed significantly to climate change of the study region, and has been presumed to be a major driver of biodiversity loss. In general, land degradation increases the number of people exposed to hazardous air, water, and land pollution.

In a similar way, comparing with what was mentioned by the Intergovernmental Panels on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC), in the article, a review of climate change: causes, effects and mitigation measures, they stated that climate change has been caused by both human activities and natural causes, including ocean currents, heat waves, et cetera. (Onoja & Enete 2011).

Figure 14 depicted below also explains the potential future effects of climate change in Karamoja.

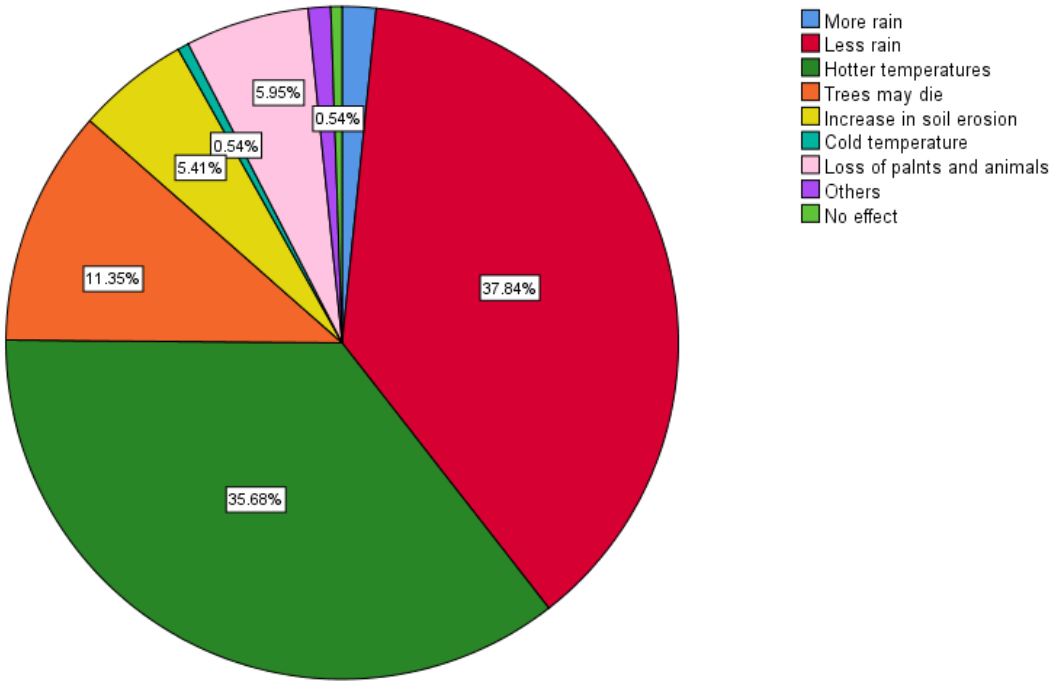


Fig 14: Future effects of climate change in Karamoja

As shown in Fig 14, the potential major future effects of climate change in Karamoja are: (37.8 %) less rain and (35.7 %) hotter temperatures. The data also showed that the potential minor future effects of climate change in Karamoja are: (11.4 %) tree death and (5.9 %) plant and animal loss. In terms of the interviews, the environment in Karamoja is not the same as it was 5 - 10 years ago. Many trees have been cut down by communities and residents for charcoal burning, firewood, and domestic uses. Consequently, the area has become bare and open (no trees), with light rains during rainy seasons.

According to a focused group discussion, the following changes in the general pattern of the environment in the Karamoja region have occurred:

a) Unpredictable and unevenly distributed rainfall with droughts from April to June, long dry spells and erratic rains from May to July, and floods from July to September.

b) Drying of surface water bodies such as dams and rivers due to high evaporation rates caused by high temperatures, resulting in water scarcity.

c) Extremely high temperatures, particularly during the dry season. Rising temperatures have the potential to increase the frequency, intensity, and duration of heat waves in the region, which in turn reducing crop and animal water availability and puts food security in jeopardy.

d) Extreme poverty has made the Karamoja communities to cut down trees for charcoal burning as a way to make a living, which in turn causes deforestation.

e) Conflicts in communities caused by cattle raids. The long dry spells have harmed the Karamojong livelihoods due to famine, forcing them to resort to cattle rustling.

f) Disease outbreaks in livestock have occurred, particularly during the rainy months of August and September.

g) Famine and drought, have put people's livelihoods in jeopardy and consequently, food prices in the region have risen dramatically.

h) Plant biodiversity has been lost as a result of bush fires, which is a significant contributor to climate change. It has made the land more susceptible to wind, water erosion, and ultraviolet radiation. Bush burning emits air pollutants such as carbon monoxide, nitrogen oxide, ozone, and other oxidants, as well as particulate pollutants such as dust, fume, mist, and smoke. These are potential sources of global warming.

i) Water pollution has resulted from the disposal of waste/garbage into the water sources, as well as the practice of open defecation in some parts of the regions. This may result in an increase in the number of water-borne diseases among Karamoja residents. Furthermore, the majority of available water sources are shared by humans and livestock, which is unsanitary because disease contamination and transmission can occur when humans consume the water or sick livestock drink from the same sources as healthy livestock.

These in agreement with other studies, the Intergovernmental Panels on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC), in the article of a review of climate change: causes, effects and mitigation measures, also state that heat waves can result into desertification, depletion of water availability, reduced animal metabolism and agricultural food production, loss of biodiversity, food insecurity as well as

decreased animal health. (Onoja & Enete 2011). In addition, Baumgard (2012) stated that, climate change has a great impact on livestock production through incidence of diseases among livestock and other animals. Most diseases are transmitted by vectors such as ticks and flies and are dependent on ambient temperature.

4.3 Climate Change

Climate change responses in Karamoja was analyzed using the mean and standard deviation. The mean shows the occurrences of a response while standard deviation portrays the extent to which the scores deviate from the mean. The detail of the findings is shown in table 4.3.

Table 4.3: Climate Change responses in Karamoja

Statements	N	Mean	St. Deviation
Climate change is occurring	185	4.5297	0.684
Human activity is responsible for climate change	185	4.3514	0.7738
Every individual can do something to adapt to climate change	185	4.2811	0.7349
Natural changes in the environment are responsible for climate change	185	3.973	0.8995
Living today is more important than worrying about the effects of climate change in many years in the future say 10, 20, 30 0r even 70 years	185	2.6919	1.097
Climate change can reduce the quality of life for the future generation	185	3.7514	1.0492
I have encountered unusual events such as floods, waves washing our walls or droughts	185	3.773	1.0121
I have lost property as a result of floods and droughts	185	3.9189	1.0779
My livestock died because of droughts	185	3.9297	1.0532
Aggregate Mean and Std Deviation		3.9111	0.9312

Source: Research data (2021)

The study's overall mean revealed that respondents agreed with the statements under consideration. A mean of 3.91 was used to represent this. The low standard deviation of 0.93 indicates that the data from the respondents is clustered around the mean. The respondents strongly agreed with the statement that, climate change is occurring. The majority of them also

agreed that human activity is to blame for climate change. Respondents also strongly agreed that everyone can do something to help the environment adapt to climate change. This was represented by a mean of 4.52, 4.35, and 4.28. The low standard deviations of 0.7, 0.8, and 0.7 indicate that the data from the respondents is dispersed around the mean. According to the study findings, respondents agreed with the statement that natural environmental changes are to blame for climate change. A mean of 3.97 was used to represent this. The low standard deviation of 0.9 indicates that the data from the respondents is dispersed around the mean. Respondents also agreed with the statement that I had lost property due to floods and droughts. According to the study findings, respondents agreed with the statement that their livestock died as a result of droughts and that they lost their properties as a result of floods and droughts. This was represented by a mean of 3.9. However, the high standard deviation of 1.07 and 1.05, respectively, indicates disparity or incoherence in the respondents' opinions about the subject matter. Studies also indicate that the consequences of climate change include extremely high and hot temperatures, which reduces rainfall expectations and has a negative impact on livestock production (Kebede, 2016).

4.4 Major Climatic factors affecting Productivity of Livestock in Karamoja

The objective of ascertaining the major climatic factors affecting productivity of livestock in Karamoja was analyzed using qualitative data from interview and focus group discussion feedback from respondents in the study area. The information gleaned was presented and analyzed qualitatively by assigning codes to create meaningful themes.

From the group discussion and interview, the major climatic factors affecting productivity of livestock in Karamoja included the following:

a) **Livestock diseases**: the extreme hot temperature brought about by climate change has affected productivity of livestock in Karamoja through affecting the health of the animals as this impact on their immune system and makes the animals more susceptible to diseases that lead to death. This in agreement with Baumgard et al., (2012), who states that temperature and rainfall variations, are the most influential climatic factors that influencing livestock with disease outbreaks. Likewise, higher temperatures, as well as erratic rainfall patterns, have a significant impact on disease pathogenic bacteria, viruses, parasites, and fungi survival in livestock.

b) **Heat stress**: is the most serious direct effect of climate change on cattle output. It costs livestock farmers a lot of money since it reduces milk component and production, meat production, reproductive efficiency, and animal health. As a result, a rise in air temperature could have a direct impact on animal performance. According to the study carried out by Chauhan and Ghosh (2014) on the effect of climate change on livestock, they found that the heat stress reduces the economic benefits of raising high-yielding dairy cattle".

c) **Livestock water source**: the increase of temperatures and the climate upheavals have led to increased evaporation rates of water points, leading to reduction in water levels and drying of many water sources in the region especially those that are seasonal. This has led to water scarcity and migration of pastoralists from one place to another in search of water and pasture for their animals which directly affects the productivity of livestock in Karamoja. This is illustrated in a photo in "Appendix VI", showing dried up Omanman seasonal river that is used for livestock watering in Moroto district of Karamoja. This is in commitment with the other study done by (USAID, 2017). It provided that the increase of temperatures and the climate upheavals have led to increase evaporation rates of water points, leading to reduction in water levels and drying of many water sources used in livestock production.

d) **Unreliable and seasonal rainfall** occurrences have led to drought in the study region especially during peaks of no rains. This in turn affecting livestock drinking water sources which alters their performance and productivity. Also, limited access or reduced water consumption can result in dehydration, which can be fatal to livestock. Mugerwa et al. (2014) stated that unreliable and seasonal rainfall occurrences impact negatively on livestock production since it leads to reduced consumption by animals.

e) **Extreme weather events** in terms of heavy rains have led to flash floods, sedimentation of river banks and canals, as well as washing of debris and sewage in the region. This has caused pollution of various water sources, affected animal mobility and animal fodder by damaging pastures and grazing lands. Polluted water sources lower water consumption or in-take by the animals. Livestock that are provided low-quality water will always tend to have reduced water and feed intake, resulting in reduced production. Furthermore, the polluted water sources when shared by sick animals could result to increased incidence of spread of infectious water borne diseases as well as challenges to hygiene/sanitation practices.

4.5 Extent to which climate change has affected water sources for animals and productivity of livestock in the study region

To address the purpose of the study aiming at assessing the extent to which climate change has affected water sources for animals and productivity of livestock in the study region, a regression analysis between climate change as an independent variable and water sources for animals and productivity of livestock as a dependent variable was conducted. The results from analysis are presented in the model summary and coefficients tables below;

Table 4.5: Regression model between climate change, water sources for animals and productivity of livestock

Model	R	R Square	Adjusted R Square	Std Error of the Estimate
1	0.847[a]	0.718	0.704	0.313
Predictor: (constant) climate change				

The regression model of climate change and water sources for animals and productivity of livestock with R^2 and adjusted R^2 of 0.718 and 0.704 respectively. The adjusted R^2 also called the coefficient of multiple determinations, is the percent of the variance in the dependent variables explained uniquely by the independent variable. An adjusted R^2 of 0.704 implies that 70.4% of the variation on water sources for animals and productivity of livestock is influenced by climate change. The remaining 29.6% of the variation on water sources for animals and productivity of livestock are as a result of other factors other than climate change. Below are the results showing the confirmation on significant levels.

Table 4.6: ANOVA test for relation between climate change, water sources for animals and productivity of livestock in the study region

Model		Sum of Squares	DF	Mean Square	F	Sig.
1	Regression	5.009	1	5.009	50.900	.000[a]
	Residual	1.968	20	.098		
	Total	6.977	21			

a. Predictor:(constant), climate change
b. Dependent Construct: water sources for animals and productivity of livestock

To confirm the relationship, another test was carried using a regression analysis which also evidenced existence of a relationship between climate change, water sources for animals and

productivity of livestock in Karamoja (Table 4.5). Since the calculated p-value of 0.000 is less than 0.05, the regression model was found to be statistically significant with the F- value of 50.90. This confirms that the model applied can thus significantly predict the change on water sources for animals and productivity of livestock as result of the climate change, as evidenced by residual values that are smaller (1.968) than the regression value (5.009).

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

This study examined the effects of climate change on livestock water sources and livestock productivity using the Karamoja region of Uganda as a case study, based on quantitative and qualitative analysis of respondent's opinions towards the subject matter. The study concentrated on the districts of Napak, Moroto, and Nakapiripirit of the Karamoja region. To achieve the main objective, the specific objectives of this study were to determine the perception of the public on climate change; to identify the major climatic factors affecting livestock productivity in Karamoja and to assess the extent to which climate change has affected water sources for animals and livestock productivity in the study region.

5.1 CONCLUSION

The conclusion is divided into three sections:

5.1.1 Perception of the Public on Climate Change

The study concluded that the general public has heard of and understands the effect of climate change on the ecological parameters. Climate change can be caused by a variety of factors, including deforestation, charcoal burning, natural events such as lake currents, carbon emissions from vehicles and industries/factories, as well as land degradation. The main effects of climate change in Karamoja are erratic and uneven rainfall, drying of surface water bodies such as dams and rivers, excessively high temperatures, especially during the dry seasons, deforestation, outbreaks of livestock diseases, especially during the rainy season, and livelihood insecurity due to famine and drought.

5.1.2 Major Climatic factors affecting Productivity of Livestock in Karamoja.

The study concluded that livestock diseases, heat stress, drying of livestock water sources especially seasonal water sources due to extreme hot temperatures, unreliable and seasonal rainfall occurrences and extreme weather events such as heavy rains are the major climatic factors affecting productivity of livestock in Karamoja.

5.1.3 Extent to which climate change has affected water sources for animals and productivity of livestock in the study region

In regard to this section, the results according to the study and analyses has shown that climate change has a positive impact on animal water sources and livestock productivity, and thus can affect the study parameters. An adjusted *R* square of 0.704 implied that 70.4% of the variation on water sources for animals and productivity of livestock is influenced by climate change, and the remaining 29.6% of the variation on water sources for animals and productivity of livestock are as a result of other factors other than climate change. Also, from the same regression table (Table 4.5), a correlation coefficient (r) of 84.7 %, shows a positive impact climate change has on animal water sources and livestock productivity, and only 15.3 % can be attributed to other factors.

5.2. RECOMMENDATION

Based on the above conclusion, the researcher recommends that;

5.2.1 To Livestock Farmers/ Herders of Karamoja Region

Climate change mitigation and adaptation strategies be implemented. Changes in production and management systems, such as livestock and crop variety diversification should be practiced to increase drought tolerance; institutional and policy changes, scientific and technological advancements, and changing farmers' perception and adaptive capacity, could all be considered adaptation measures. Mitigation strategies could include carbon sequestration through reduced deforestation and increased afforestation; improving manure management by improving storage and handling practices is the other mitigation measure (reducing storage time, improving housing systems to handle manure). This has the potential to lower greenhouse gas emissions as well. Efficient fertilizer use, such as the use of organic fertilizers and the combination of legumes and grasses in pasture areas, can help to reduce GHG emissions in feed production. Some of these adaptation and mitigation strategies, on the other hand, are already in place and being implemented in the region, though they will require significant public policy support to be more effective.

Further research and studies in this area of climate change adaption and mitigation should as well be conducted to cover up the knowledge gap.

5.2.2 To the Government and Development Partners

a) The Ugandan government, NGOs, and all concerned individuals should conduct massive tree planting (agroforestry) awareness and sensitization campaigns. This is to raise awareness among Karamoja sub-region communities about the value of trees in their environments, such as water conservation and desertification mitigation. Moreover, the government of Uganda, NGOs, and research institutes involved, such as those in climate change sections, can advocate for widespread climate change awareness creation and sensitization programs, explaining to the people of the Karamoja sub-region the drivers and impacts of climate change, the various adaptation and mitigation options available locally, and how to implement them. This can also be achieved through providing access to climate change information.

b) In order to improve water availability for people and livestock productivity, the government of the Republic of Uganda and development partners have undertaken a number of water projects in Karamoja, such as, rain water harvesting structures to improve water availability for use during the dry seasons and in agroforestry schemes. This including borehole drilling and the construction of valley dams and water ponds. They are insufficient, however, to meet the needs of the Karamoja people and their livestock. As a result, the government of Uganda, non-governmental organizations (NGOs), and responsible ministries should invest significantly in providing more water sources and constructing more valley dams/dams throughout the Karamoja sub-region to improve water availability and combat water scarcity issues.

c) In collaboration with organizations such as OXFAM and the United Nations Development Programme (UNDP), the government of the Republic of Uganda has also built a total of 43 water pumping windmills throughout the Karamoja subregion in order to increase water availability, utilization, and management, as well as livestock productivity (MoFPED, 2017). This is according to the Government of Uganda's (GoU) second National Development Plan (NDP II) (Republic, 2019), that was for F/Y 2015/16 to 2019/20. According to the report, however, only 18 percent of the windmills in the region are operational, while the remainder are non-functional, with the majority either not working, removed, abandoned, or vandalized. As a result, the government should put in place security measures at the site to prevent such incidents, and recipient local governments and communities should be encouraged to keep existing windmills operational.

d) Improving the capacity of all organizations and institutes involved in climate change mitigation in the Karamoja sub-region. This can be through the implementation of remote sensing techniques and geographic information systems (GIS) to allow one to obtain up-to-date data on climate change trends that help predict disaster risks such as floods and drought, and guide disaster relief efforts.

e) The Republic of Uganda's government (both central and local) must improve the provision of extension/advisory services in the sub-region so that climate adaptation measures can be popularized and scaled up.

f) For timely and adequate climatic information, early warning systems should be a priority area for investment in the Karamoja region. This is because the findings show that these systems are severely constrained in the research area.

g) Water contaminant identification is a critical component in the community's management of the associated problems. From the perspective of water quality specialists or veterinarians, knowledge of how to recognize the various problems associated with water contaminants is unquestionably essential for the rapid detection of problems and effective management of the adverse effects. Livestock producers, on the other hand, should have a basic understanding of the potential negative effects of water contaminants.

5.2.3 Policy Recommendations

With reference to the National policies of Uganda that are in line with this study, a number of gaps have been identified by the researcher; including weak inter-sectoral and institutional coordination since there are a number of agricultural supporting sectors involved. For example, in the 2011 National Agricultural Policy of the Republic of Uganda, (MAAIF, 2011), Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), is mandated to manage and coordinate agricultural policy and interventions of the country. However, there are other statutory semi-autonomous institutions under MAAIF such as NARO, local governments and other agricultural support sectors in water, environment and natural resource sectors, agricultural finance, et cetera., each with its specific objectives, strategies and roles to play. This has led to overlap of responsibilities and duplication of efforts. As a result, the researcher suggests that the government establish a planning and coordinating framework that connects MAAIF with other statutory semi-

autonomous institutions and supporting sectors to ensure that the policy is implemented effectively.

The Uganda National Climate Change Policy (2015) has one of its policy priorities being climate change information sharing, but there is still limited data and information on weather predictions, climate change as well as dissemination of the available relevant data. (MWE, 2015). This has made early warning on climatic shocks difficult, hence, adequate climatic information sharing should be emphasized at all levels for timely warning.

Other policy recommendations to boost livestock productivity and to reduce the effects of climatic shocks could include; encouraging and supporting dry-season livestock feeding by preserving pastures and using other feeding methods.

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Appendix I: Questionnaires

Dear Respondent

My name is Sandra AUMA a student of Pan African University Institute of Water and Energy Sciences (including climate change), Algeria, conducting an Academic Research as a partial requirement for the award of Master of Science Water Policy Degree. You have been considered and chosen one of the respondents and therefore you are requested kindly to spend a few minutes of your time to answer the questions in this questionnaire. The information given will be used strictly for academic purposes only.

A) Social- Demographic factors

1) Gender Male [1] Female [2]

2) Age 18-25 [1] 26-35 [2] 36-44 [3] 45-53 [4] 54-62 [5]

63- Above [6]

3) Which district of Karamoja do you live? …….

4) How many years have you lived here?

Less than 1 year [1] 1-5 years [2] 6-10 years [3] 11-15 years [4]

16 years and above [5]

5) Education Level
No formal Education [1] Primary [2] UCE [3] UACE [5] Degree [4]

Master's Degree [5] Other Specify…… [6]

6) Employment type
Government employee [1] Religious Institution [2] Small business- personal [3]

Small business- for another [4] NGO worker [5] Retired civil servant [6]

House wife [7] Student [8] House wife [9] Unemployed [10]

Other Specify…… [11]

B) Knowledge of Climate Change

7) Have you ever heard about climate change?

[1] Yes [2] No

If the answer is no and you don't know what climate is then climate change are changes being experienced in our environment. Do not answer question 8 but proceed to question 9, if you say yes then continue with question 8

8) If you have ever heard about climate change, can you say you understand what climate change is

[1] Yes [2] To some extent [3] No

9) In your own opinion do think or believe that climate change exists?

[1] Yes [2] No [3] I don't Know

If the answer is yes, in your own opinion, what do you believe are the likely causes of climate change?

[1] Deforestation [2] Burning Charcoal [3] Natural events such as lake currents

[4] Carbon emissions from vehicles and industries/ factories [5] God

[6] Agricultural factors like methane from livestock, manure and nitrous oxide emission from fertilizers

[7] Other specify……. [8] I don't know [9] it doesn't exist

10) Have you heard of anything about possible future effects of climate change in Karamoja? If so, which of the following?

[1] More Rain [2] Less rain [3] Hotter temperatures [4] Trees may die

[5] Increase in soil erosion [6] Cold temperature [7] Loss of plants and animals

8	I don't know	9	other specify	10	No effect

C) Climate Change

Likert Scale: 5. Strongly Agree 4. Agree 3. Neither Agree nor Disagree 2. Disagree 1. Strongly Disagree

No.	CLIMATE	1	2	3	4	5
9	Climate change is occurring					
10	Human activity is responsible for climate change					
11	Every individual can do something to adapt to climate change					
12	Natural changes in the environment are responsible for climate change					
13	Living today is more important than worrying about the effects of climate change in many years in the future say 10, 20, 30 0r even 70 years					
14	Climate change can reduce the quality of life for the future generation					
15	I have encountered unusual events such as floods, waves washing our walls or droughts					
16	I have lost property as a result of floods and droughts					
17	My livestock died because of droughts					

D) Climate Change and Livestock Water Sources

Likert Scale: 5. Strongly Agree 4. Agree 3. Neither Agree nor Disagree 2. Disagree 1. Strongly Disagree

No.	**Water sources**	1	2	3	4	5
18	I use mostly underground water sources for my livestock					
19	I use mostly surface water for my livestock					
20	I always harvest rain water for my livestock					
21	Ground water recharge is affected with a reduction in the availability of ground water, thereby affecting drinking water for livestock					
22	At times the level of the surface water increases abnormally					
23	At times the level of surface water reduces abnormally					
24	At times we don't have harvested rain water because of long dry spell					
25	At times, there are increases in the occurrence of flooding due to heavy rainfall events.					
26	My livestock lacks water for drinking due to water scarcity					

E) Climate Change and Livestock Productivity

Likert Scale: 5. Strongly Agree 4. Agree 3. Neither Agree nor Disagree 2. Disagree 1. Strongly Disagree

No.	**Livestock Production**	1	2	3	4	5
27	The number of my livestock has increased in the last three years due to good health and good climatic conditions					
28	I have registered high sales of my livestock in the last three years because of good health					
29	My livestock weighs averagely very high number of Kilograms in weight due to availability of feeds, water, pastures and good health					
30	My livestock can attract very high prices					
31	In the next three years I expect to have very high number of livestock if climatic conditions are favorable					
32	My livestock suffer from ticks and diseases due to changing climatic conditions					
33	I have enough land for grazing animals and enough space to allow me keep big number of livestock.					

Thank you

Appendix II: Interview Guide

Dear Respondent

My name is Sandra AUMA a student of Pan African University Institute of Water and Energy Sciences (including climate change), Algeria, conducting an Academic Research as a partial requirement for the award of Master of Science Water Policy Degree. You have been considered and chosen one of the interviewees. I therefore kindly request you to spend a few minutes to answer the questions during this interview. The information given will be used strictly for academic purposes only.

PART- A: Climate Change

1- Please can you tell me your Name (Optional)……
2- How old are you?.....
3- How long have you stayed / lived here?.....
4- Please can you tell me what you know about climate change is……
5- What do you think are the main causes of climate change in Karamoja? Tell me about three
   i) …….
   ii) …….
   iii) …….
6- a) As you see the environment in Karamoja today, is it the same as it was 5, 10 years ago?
   b) If it is not the same what do think has happened?.....
7- In your own view what do you think should be done to change what is happening to the environment in Karamoja area?.....
8- What can you tell me about the temperatures in Karamoja today in comparison to five, ten years ago?.....
9- a) what can you say about the natural trees in Karamoja are they increasing or decreasing/
   b) If they are decreasing what has made it to decrease?.....

PART B: Climate change and Water Sources

10- What are the main sources of water used for livestock in Karamoja?.....
11- What are the main issues you have encountered with the above water sources in recent past?.....
12- What changes if any do think may happen on the water sources you have mentioned in No. 10 above in the near future?…….
13- What can you say about the water sources used by livestock in Karamoja in terms of its adequacy and quality?

PART C: Climate change and Livestock Productivity

14- What can you say about the livestock health in Karamoja/ your district…….?
15- In your own opinion do you think the number of animals in Karamoja/ your district has increased in the last three years? If yes, why do you think so?.....
16- What can you tell me about the prices of cattle, pigs, goats and sheep in Karamoja and what determines the prices?.....
17- What can you tell me about the sizes of cattle, pigs, goats and sheep in Karamoja/ your district in terms of their weight?.....
18- What is the level of livestock sales in your district say in a year? You can state averagely in numbers?

Thank you

Appendix III: Guide for Focus Group Discussion

Dear Respondent

My name is Sandra AUMA a student of Pan African University Institute of Water and Energy Sciences (including climate change), Algeria, conducting an Academic Research as a partial requirement for the award of Master of Science Water Policy Degree. Your group has been chosen to talk about issues to do with climate change (our environment), livestock productivity and water sources for our livestock. We will engage in a 30 minutes discussion and expect some response from you on these topical issues. The information given will be used strictly for academic purposes only.

- The discussion starts by introducing the moderator and Assistant who will be taking down the records/minutes of discussion
- Allow the group members introduce themselves
- Inform the members that the discussions are divided into three parts A: Climate Change B: Climate change and livestock water sources and C: Climate change and livestock productivity
- Get into the discussion

QUESTIONS : PART A - Climate Change

1. Members could there be any one among us here who knows what climate change is?
   If no one answers in the affirmative explain to them that climate change is the changes we experience in our environment example floods, droughts, high temperatures so that the group can understand the topic and then continue to question 2
2. I am aware most of us if not all of you have lived here for more than five years. If so, dating back to that time, what changes have we experienced in the general pattern of our environment?.....
3. Can each one of us come with a list of at least three or more things we know are some of the causes of climate change
4. From the answers we have given above what do you think are the dangers it has caused on our people here in Karamoja/ District
5. What should be done or what do you think can be done to control or mitigate the effect of climate change? Can each one of us give at least two things which can be done
6. What can you say about the temperatures of Karamoja/ your district in the recent past if you compare with it 5 or 10 years ago?
7. What can you say can be the causes of the disparities in the temperatures as you have talked about in our last question (Question 6)
8. Members I am aware as individuals we can do something to protect the environment. Can each of us mention at least two things we should do to protect our environment?

9. How about the government and non-governmental Organisation what should they do to help us with the problem of climate change?
10. Is there anything you want to say about the issue of climate change which you feel we have not talked about?.....

QUESTIONS: PART B - Climate Change and Livestock Water Sources

1. What do we understand by sources of water meant for livestock?
2. Please can you tell me the different sources of water used for drinking by livestock Karamoja/your district?
3. What are the likely dangers do think Karamoja is bound to face in the near future on its water for livestock as a result of climate change?.....
4. What can you say about the quality of water used for drinking by cattle, sheep, goats and pigs in Karamoja/ your district?
5. If the quality is not good, why do you think it is so?.....
6. Is there anything the community, you as an individual or government can do to improve the quality of water used for drinking by domestic animals in Karamoja / your district?.....
7. Is there any other think you feel is important about the different sources of water used by livestock in your district/ Karamoja? If so, what are those things? Please elaborate…….

QUESTION: PART C- Climate Change and Livestock Productivity

1. Generally speaking, what can you say about the total numbers of cattle, sheep, goats and pigs and chicken in your district/ Karamoja?
2. Members do we see an increment in the number of cattle, sheep, goats, and pigs in your district in the next three to five years if so in what range?.....
3. Let's talk about sales of livestock in your district. What can you say about the numbers of animals being sold every year in your district and the prices?
4. What can you say about the sizes of Cattle, goats, sheep and pigs in your district in terms of their weight in Kilograms, the ones which are ready for sale? Does the weight depend on the health of the animals, and/or does it fluctuate depending on the availability of water and pastures for the animals?
   i) The biggest Bull weighs between …… Kg (Average) and ……. Kg (Average)
   ii) The biggest Cow weighs between …… Kg (Average) and ……. Kg (Average)
   iii) The biggest goat weighs between …… Kg (Average) and ……. Kg (Average)
   iv) The biggest Sheep weighs between …… Kg (Average) and ……. Kg (Average)
   v) The biggest Pig weighs between …… Kg (Average) and ……. Kg (Average)
5. Members what can you say generally about the prices of domestic animals in your district/ What determines the prices?.....
6. Let's talk about animal health/ diseases. Are the domestic animals in Karamoja suffering from animal diseases? If yes, what do you think are causing these diseases?

7. a) Let's talk about land for grazing and animal feeds. Is there enough land for grazing animal in Karamoja/ your District if No. why do think the land is not enough? Each member to state at least two factors

   b) How about the animal feeds like grasses. Is it enough if no, what is the cause of its inadequacy?
8. Is there any other think you feel is important about the different sources of water used by livestock in your district/ Karamoja? If so, what are those things? Please elaborate…….

Thank You

Appendix IV: Informed Consent Form

TOPIC: ASSESSMENT OF THE IMPACTS OF CLIMATE CHANGE ON LIVESTOCK WATER SOURCES AND LIVESTOCK PRODUCTIVITY IN THE KARAMOJA REGION

INTRODUCTION

My name is Sandra AUMA and I am carrying out a research project looking at the impacts of climate change on livestock water sources and livestock productivity, case of Karamoja region. This research is conducted by a Master's student at the Pan African University Institute of Water and Energy Sciences (including Climate Change) (PAUWES), University of Tlemcen, Algeria. Therefore, as one of the chosen participants of this study, i would like to ask you a set of questions. I value your opinions and there are no wrong answers to the questions i will be asking. This study is conducted anonymously. That means, that any information which may lead to you will be anonymized. Thus, a researcher who uses the data will never be able to identify you, except with your explicit permission. All the answers which you will provide will therefore be used for study purposes only and will be treated confidential. Your participation in this research is completely voluntary as well. You are free to withdraw your consent and discontinue answering these questions at any time.

I require just a few minutes of your time to complete the survey. I will appreciate your endeavors to answering all the questions to the best of your abilities and knowledge, and I will give you an opportunity at the end of the interview/discussion to review your remarks, and you can ask to modify or remove portions of those, if you do not agree with my notes or if I did not understand you correctly.

INFORMED CONSENT

The above statement has been read to me (or I have read it myself) and its meaning has been explained by the research staff. I agree to take part in this research. I understand that I am free to discontinue participation at any time if I so choose and that the research staff/contact person will answer any questions that arise during the course of the survey.

____Yes, I agree to participate. Interview Start Time: _____ End Time: _____

____ No, I do not wish to participate. (Discuss with Supervisor and move to the next participant)

Print name of the participant: _____

Signature of Participant: _____ Date: _____

Signature by the researcher: _____

Appendix V: Table for determining sample size from a given Population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	276	4500	351
35	32	150	108	360	181	1100	285	5000	357
40	36	160	113	380	186	1200	291	6000	361
45	40	180	118	400	196	1300	297	7000	364
50	44	190	123	420	201	1400	302	8000	367
55	48	200	127	440	205	1500	306	9000	368
60	52	210	132	460	210	1600	310	10000	373
65	56	220	136	480	214	1700	313	15000	375
70	59	230	140	500	217	1800	317	20000	377
75	63	240	144	550	225	1900	320	30000	379
80	66	250	148	600	234	2000	322	40000	380
85	70	260	152	650	242	2200	327	50000	381
90	73	270	155	700	248	2400	331	75000	382
95	76	270	159	750	256	2600	335	100000	384

Source: R.V Krejcie and D.W Morgan (1970)

Appendix VI: Field Photos

Field photos of some water sources used for livestock watering in Moroto District

Omanman Seasonal River

Lokwakwa Village Water Tap in Nadunget SB

Nabokat water Pond

Water Sources used for Livestock Watering in Napak District

Nakicumet Valley Dam located in Matany Sub- County, Nakicumet Village

Water Pumping Windmill of Napak District, located in Loodoi, Namoruongora Village; Matany Sub- County.

Field Photos of Focus Group Discussions carried out with the Elders, LC1, Youths, Farmers and Herders in the three Districts of the study area.

Focus Group Discussion in Moroto District

Focus Group Discussion with of Napak

Focus Group Discussion in Nakapiripirit District

Appendix VII: Thesis Budget Report

Student's Name: AUMA Sandra

Topic: Assessment of the impacts of climate change on livestock water sources and livestock productivity in the Karamoja Region of Uganda.

S/N	Item & Date	Unit	Quantity	Rate (Unit price) UGX / DZD	Rate (Unit price) USD	Total Cost USD	Link to Research Activity**
	(A) Materials and Supplies						
1	Internet recharge (May to September)	Monthly	5	100,000 UGX	28.41	142.05	Downloading papers, journals, and video tutorials
2	Printing of data collection tools 26/06/2021	Questionnaires each 4 pages	185	500 UGX	0.14	105.1	185 questionnaires each of 4 pages were printed for the 3 sampled districts of Karamoja
		Interview forms each 2 pages	35	500 UGX	0.14	9.94	35 interview forms each of 2 pages were printed for the 3 sampled districts of Karamoja
		Consent forms (1 page)	35	500 UGX	0.14	4.97	35 consent forms single page each were printed for the 3 sampled districts of Karamoja
		Focus group discussion forms each 3 pages	3	500 UGX	0.14	1.28	3 focus group discussion forms each of 3 pages were printed for the 3 sampled districts of Karamoja
3	Printing of thesis draft report with spiral comb binding 09/10/2021	1 Report of 63 pages	500 UGX printing per page & 5000 spiral binding	31,500 UGX 5000 UGX	10.3	10.3	For personal proof reading and final corrections
	Sub Total					**273.64**	
	(B) Travel						

1	PCR Test in Algeria 03/05/2021		1	9,500 DZD	70.43	70.43	Covid-19 test was required in order to travel
2	International return ticket		2	136,251 DZD	1034.7	1034.7	Travelling for Internship and Research
3	Local Travel (Tlemcen to Algiers airport) 05/05/2021	519.1 km	1	15,000 DZD	111.15	111.15	Taxi hire (Pick from Tlemcen to Algiers airport).
4	Taxi hire (from Entebbe International airport to Moroto) 06/05/2021	540.6 km	Car Hire Fuel at 4,150 UGX (1.17 USD) = 80 liters [14 litres/ 100km] Driver	150,000 UGX 332,000 UGX 100,000 UGX	43.3 93.7 28.2	165.2	For Research Internship
5	Disposable Masks and Hand Sanitizer Gel (May to September) 06/05/2021	Days	Masks: 3 boxes. 100,000 UGX per box Gel: 5 bottles @ of 250 mls	300,000 28,000 UGX @ bottle	85.23 39.77	125	Covid-19 safety measures
	Sub Total					**1506.48**	
(C) Field Transportation (02/08/2021 to 20/08/2021							
	Field Transportation for data collection in the 3 districts.	Days	15 days				

1	Car Hire and Driver	15 days	140,000 UGX per day	2,100,000	39.5 USD	592.5	The costing included cost of car hire, driver, fuel consumption and language translator. This enabled easy data collection from respondents in the 3 districts of Karamoja (Moroto, Napak and Nakapiripirit.
2	Apac to and fro Moroto (305.9 km + 36 km) = 341.9 km	5 days	Fuel at 4410 UGX (1.2 USD) 1 litre for 7 kms = 49 litres	216,090 UGX	60.97	60.97	
3	Moroto to and fro Napak (49 km + 31 km) = 80 km	5 days	Fuel at 4410 UGX (1.2 USD) 1 litre for 7 kms = 11.4 litres	50,274 UGX	14.18	14.18	
4	Moroto to and fro Nakapiripirit (120.9 km + 14 km) = 134.9 km	5 days	Fuel at 4410 UGX (1.2 USD) 1 litre for 7 kms = 19 litres	83,790 UGX	23.64	23.64	
5	Local Translator	15 days	21,119 UGX per day	316,785 UGX	6 USD	90	
	Sub Total					**781.29**	

SUMMARY		
A	Material & Supplies	273.64
B	Travel	1506.48
C	Field Transportation for data collection	781.29
	Grand Total	**2,561.41 USD**
3000		

NB: UGX= Ugandan Shillings; DZD= Algerian Dinars; USD= United States Dollars