MAKERERE UNIVERSITY

COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

SCHOOL OF AGRICULTURAL SCIENCES

ASSESSING THE EFFECTIVENESS OF CLIMATE CHANGE ADAPTATION INTERVENTIONS BY AGRO-PASTORALISTS IN NABISWERA SUB-COUNTY NAKASONGOLA DISTRICT

BY

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REG NO. 16/U/6383/PS

A SPECIAL PROJECT REPORT SUBMITTED TO MAKERERE UNIVERSITY

SCHOOL OF AGRICULTURAL SCIENCES DEPARTMENT OF AGRICULTURAL PRODUCTION IN PARTIAL FULFILLMENT OF THE AWARD OF A DEGREE OF BACHELOR OF SCIENCE IN AGRICULTURAL LANDUSE AND MANAGEMENT

JANUARY, 2023

DECLARATION

I, Kusiima Amon, hereby declare that this special project report titled "**Assessing the effectiveness of Climate Change Adaptation Interventions by Agro-Pastoralists in Nabiswera Sub-county**" is my original work and has never been submitted to any university or institution of higher education for any academic award.

SIGNATURE.......................... DATE 03/01/23

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APPROVAL BY ACCADEMIC SUPERVISOR

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DEDICATION

I dedicate this book to my late Dad Mr. PAUL RURUNGI and my loving Mom Mrs. MARY RURUNGI, my dear siblings and the rest of the family for their continued support and encouragement through my research project process. May God richly bless you.

ACKNOWLEDGMENT

I am so thankful to God for good health and ability to put this work to completion.

My sincere appreciation goes out to my academic supervisor Dr. Zziwa Emmanuel Department of Agricultural Production, Makerere University, for the guidance, encouragement, time and patience accorded unto me from the start of this research until its completion. I also thank Mrs. Nampijja Zainah for the guidance and editorial skills through my writing process.

I am forever indebted to my supportive and loving family, my elder brother Mr. Kandwanaho Jonan, for his financial support and believing in me My Dear Mom, Mrs. Mary Rurungi for her continuous prayers, financial and emotional support rendered unto me and the entire family that helped me in one way or the other.

Lastly, I thank all my fellow classmates and friends who guided me during our course of study to perfect my research work.

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ABREVIATIONS AND ACRONYMS

CCA	Climate Change Adaptation
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GHG	Green House Gasses
GIZ	Gesellschaft Für Internationale Zusammenarbeit
GoU	Government of Uganda
IOM	International Organization for Migrants
IPCC	Intergovernmental Panel On Climate Change
LULUCF	Land-use, Land-use Change and Forestry
MCA	Multi-Criteria Analysis
NDP	National Development Plan
PRA	Participatory Research and Analysis
SALM	Sustainable Agricultural Land Management
UNFCCC	United Nations Framework Convention on Climate Change

ABSTRACT

Farmers' adaptation to climate change is still low and this leaves them vulnerable to hunger and poverty during harsh climatic conditions. This study aimed at increasing adaptation by Agro-pastoralists in Nabiswera sub-county to climate change and was achieved through the following objectives; 1) determining the farmers' perception on climate shocks and their effects to Agro-pastoralists communities in Nabiswera Sub-county, 2) determining the effectiveness of climate change adaptation interventions by the Agro-pastoralists in Nabiswera Sub-county. The study was conducted in Nabiswera sub-county, Nakasongola district using a structured questionnaire on 43 farmers who were purposely selected to include only those that had stayed in the area for over 20 years who could give viable data about the climate change in their communities. The results of the study showed that all farmers (100%) were aware of the changes in the climate and had experienced the effects and hardships associated with these changes. There has been a decrease in the amount of rains received annually, with the most decrease happening in the 1st rainy season between March to May with a percentage of 100% decrease as reported by farmers interviewed in the sub-county. This decrease has been reported to have started happening in the previous two years for example, from late 2020 to early 2022. The dry season temperatures have been observed to increase as reported about by all farmers (100%) as the intensity of wind in the dry season increases where 60.5% farmers reported about this, and it was due to increased drought season that was observed by most households interviewed in the sub-county. The percentage of farmers who have reported the increase in drought frequencies were (90.7%) which was the biggest hindrance to their agricultural production in the area. Some of the major impacts climate change has had on farmers were failure of the annual and perennial crops, low and/or no crop yields at all, outbreak of pests and diseases, termites surge and destruction of both pastures and crops. The analysis showed that the most effective adaptation measures for crops that were used by farmers to overcome harsh climatic conditions were; planting drought resistant crops with the mean rank of 4.75 followed by the early planting with the mean rank of 4.00 and the least effective being shifting from crops to livestock with the mean value of 2.86 whereas the adaptation measures used by the livestock farmers were; stocking rate control with the mean value of 4.05 as the most effective followed by fencing off grazing fields with the mean rank of 3.94 and the least effective measure was planting drought tolerant pastures with mean rank of 2.00. The most effective adaptation measures for soil and water conservation were through the use of fertilizers with the mean rank of 5.00 followed by the use of manures with the mean value of 4.31 and the least effective measure was water harvesting with the mean value of 3.50. Due to less knowledge coverage for the improved and proven climate adaptation measures in the community, famers need to be trained and sensitized on the better approaches to climate adaption measures through their trusted model farmers in cooperation with the government extension workers who are able to train the farmers step by step adaptation procedures until a certain set goal is achieved.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Despite the worldwide advancement in agricultural technologies, the amount of degraded agricultural land continues to increase annually; this threatens the livelihoods of many communities that are wholly dependent on agriculture. Research shows that land degradation stretches to about 30% of the total global land area and is occurring across all agro-ecologies (Nkonya et al., 2016). The total number of food insecure people in the globe is therefore increasing and is mainly attributed to the direct or indirect consequence of poor land management. This reveals the enormous magnitude of the vicious cycle of agricultural production systems that operate in most of the rural areas which generate income for livelihood security from the land resources. And the biggest concern is the huge degradation of land resources as a consequence of over-exploitation and improper technologies coupled with inadequate infrastructure to transfer appropriate technologies (Praharaj et al., 2014). This has caused an increase in social issues such as unemployment, low income, food insecurity, loss of bio-diversity and above all, environmental pollution which has considerably contributed to climate change.

Climate change is an impediment to development and affects agricultural production, food security and livelihoods in sub-Saharan Africa due to rain-dependent agricultural production system (Deressa et al., 2010; Nhemachena et al., 2008). Agricultural production in Uganda is vulnerable to climate change because the agricultural regime is rain fed and subject to climatic changes and variability which are now frequently affecting agricultural productivity, leaving rural communities livelihoods food insecure (Okonya et al., 2013). Agriculture has for long been the cornerstone of Uganda’s economy in terms of contribution to the country’s gross domestic product (GDP). For instance, it comprises of about 23.7 percent of the total GDP, employs about 73.0 percent of the labour force, and accounts for 47.0 percent of the country’s total export (NDP, 2010). According to Okonya et al., (2013), the agricultural sector is dominated by small-scale farmers of mixed crop and livestock production with low productivity undermined by traditional farming practices such as lack of soil and water conservation practices, poor complimentary services such as farm-to-farm extension services and occurrence of extreme weather events such as prolonged drought, flash-floods and soil erosion. The climate change effect has increasingly become a problem in Uganda, with more severe effects in drier parts of the country like the cattle corridor.

The cattle corridor runs from the South-west to the North-east direction, from the Rwanda border to the Sudan/Somalia/Kenya borders and it is mainly covered by rangelands. The Uganda rangelands exhibit most of the characteristics of rangelands; low and erratic rainfall regimes leading to frequent and severe droughts, and fragile soils with weak structures which render them easily eroded (Kisamba-mugerwa., 2001). Agro-pastoralism is the main economic activity and rangelands are traditionally mainly used as a common pool resource.

Climate variability is an intrinsic feature in pastoral areas with both seasonal and inter-annual variations in water and pasture availability (Byenkya et al., 2014). With areas such as Nakasongola with degraded rangelands being severely affected by the climate change. Over the years, farmers have developed adaptation and land management strategies to cope with the increasing changes in climate. It is therefore necessary to document the effectiveness of climate change adaptation interventions and their linkage to climate change to guide on sustainable development of communities. This study therefore has identified these land management practices and how they have enabled farmers adapt and mitigate climate change.

1.2 Problem Statement

There are several adaptations and climate change interventions Agro-pastoralists come up with and keep on adapting. These coping strategies have been put forward by various studies which include: planting different crop varieties, changing land size, irrigation, crop diversification and changing from farming to non-farming strategies (Okonya et al., 2013; Maponya et al., 2012; Deressa et al., 2010;). However, the effectiveness of these interventions is not known and this limits the rates of adoption because when farmers use some of them they result into mal-adaptations and this limits the rate of adaptations to climate change. Therefore, through this study a number of adaptations interventions were identified and their effectiveness assessed to help farmers make informed decisions. These studies are informative in nature, however, they do not address area specific challenges like for the case of Nabiswera sub-county.

In addition, Climate change does not happen in isolation (Oxfam., 2008). It interacts with existing land management challenges and makes them even worse. Adaptation has to start with adaptation to the current climate and land management situation. This study postulates that climate is changing, and given that it has in the past, and will continue in the future, therefore underpins the urge to understand how the climatic change adaptation interventions adopted in the cattle corridor are helping farmers to adapt to climate variations.

1.3 Objectives of the study

1.3.1 Main objective of the study

1. To increase adaptation of agro-pastoralists in Nabiswera Sub-county to Climate Change

1.3.2 Specific objectives

1) To determine farmers' perception on climate shocks and their effects in agro-pastoral communities in Nabiswera Sub-county
2) To determine the effectiveness of Climate Change Adaptation interventions by the agro-pastoralists in Nabiswera Sub-county

1.4 Research questions

1) What are the farmers' perception on climate change in Nabiswera Sub County?
2) How effective are the adaptation interventions practiced by Agro-pastoralists in Nabiswera sub-county?

1.5 Significance of the study

This study is to assumptions about the effectiveness of a certain set of Climate Change Adaptations interventions countering the potential adverse impacts of identified climate risks. The assessment helps ground investment decisions in localized information and data on CCA interventions and preservatives from households, community leaders and institutional stakeholders. Nakasongola District was selected as the study area because of its specific location in the center of the cattle corridor. Nakasongola rangelands were identified as a 'hot spot' with severe land degradation, pasture and water scarcity that were translating into high livestock mortality and poverty. The District has hence received a national attention to help solve the environmental problems and save dependent communities (Zziwa., 2011).

The climate change intervention approach for mitigating climate change has both a direct link to combating climate change and its effects, and positive benefits for livelihoods, food security and poverty. In order to achieve sustainable development, it is necessary that land resource management be taken as a critical issue. Regardless of its underlying causes, climate change influences disaster risk profiles and exacerbates environmental hazards that have a further impact on development processes (Busingye., 2010). It is imperative to examine how farmers understand the effectiveness of climate change intervention measures and how these measures have enabled them to adapt to climate change. Their viewpoints can help create strategies for responding to climate and ecosystem changes in an appropriate and practical manner (Kusakari et al., 2014).

The Agro-pastoralists in Uganda's cattle corridor are more susceptible to the effects of climate change and require the most reliable climate adaptation measures to combat these effects. With less uptake of these measures, factors limiting adoption of these measures by Agro-pastoralists need to be understood. It is through farmers' knowledge, attitude and knowledge that these factors can be determined. The agro-pastoralists in Nabiswera put a lot of emphasis on agricultural production, but climate change could adversely impact on their agricultural production and understanding the link between their climate change adaptation intervention strategies is critical in helping farmers overcome their adaptation challenges.

CHAPTER TWO
REVIEW OF LITERATURE

2.1 Climate change

The United Nations Framework Convention on Climate Change (UNFCCC) defines “climate change” as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (IPCC 2001). Greenhouse gases (GHGs) that are released by human activities are responsible for climate change and global warming. The release of GHGs has triggered an increase in temperature that affects weather patterns like rainfall at the local level. Human activities that cause climate change include: burning fossil fuels (coal, oil and gas) through cooking and lighting as well as in vehicles, careless use of fertilizers, careless handling of cow dung, keeping many heads of livestock, over tilling land, burning crop residues, cutting down trees. Most studies show that average global temperature has increased by 0.5^{o} - 0.74^{0} Celsius over the past 100 years (1906-2005), and projections through climate change modeling predict the temperature could increase by at least 1.1^{o} C by the year 2100 (Recha et al., 2014).

Climate change and variability is one of the biggest global threats to agricultural production for the current and future generations. There is evidence that climate change has greatly modified the hydrological cycles, rainfall and temperature patterns in many parts of the world (Stagl et al., 2014; Kumar, 2012). The effects of climate change and variability, however, vary across regions, farming systems, households and individuals. The combined effects of all these occurrences put a strain on the livelihoods of smallholder farmers, especially in developing countries. The vulnerability of developing countries to climate risks is based on the reliance of these countries on rain fed agriculture (Quan and Dyer, 2008). According to World Bank (2010), climate change and variability would cause a decline in annual gross domestic product of 4% in Africa if no adaptation measures are taken. The situation is of greater concern in Sub-Saharan Africa where per capita food production has been declining (World Bank 2010).

2.1.1 Climate change in Uganda

Basing on the climatic models for Uganda, the country experiences high variability and high temperatures and reduced rainfall and increased rainfall variability reduces crop yield and threaten food security and livelihoods (NDP, 2010). The effects of climatic shocks and extreme weather events take toll on the small-scale farmers and the fact that climate has changed in the past and will continue to change in the future underlines the need to understand how farmers perceive and adapt to climatic change impacts to guide future coping strategies to minimize the negative impacts (Hepworth and Goulden., 2008).

In Uganda, studies have shown that much of the country's agricultural production is rain-fed, meaning that changes in weather conditions have important implications for households' total agricultural production and well-being (Asiimwe and Mpuga., 2007). The agricultural output as a share of the total GDP has declined over the years and this could be attributed to the poor traditional agricultural practices and over dependence on natural resources, so that variations in rainfall pattern significantly affect the agricultural output and thus farm incomes for the small-scale farmers with low capacity to adapt to climate changes. This volatility output due to climatic variability and extreme weather events could mean a large burden for low-income small-scale farmers unable to acquire adaptation technology and many times lacking farm-level extension services support, credit and insurance services and critical agronomic inputs (Okonya et al., 2013).

According to (Parry et al., 1999), climatic changes and variability directly affects agricultural production given that the sector is sensitive to climatic changes and precipitation variability and therefore making small-scale farmers vulnerable. (Orindi et al., 2005) also observes that Uganda is vulnerable to climatic changes and variability and this situation could amplify and worsen food security, households' poverty, and poor health given the projections of warming temperature for the county. Climatic changes are happening in Uganda. There is more erratic rainfall in the March to June rainy season, bringing drought and reductions in crop yields and plant varieties; on the other hand, the rainfall, especially in the later rains towards the end of the year, is reported as coming in more intense and destructive downpours, bringing floods, landslides and soil erosion.

2.2 Inter-linkages between climate change and agriculture

Climate change is affecting agriculture by interfering with the efficiency of crop production. Agriculture is facing droughts, flooding, sea level elevations, natural disasters, and health hazards for employees. All of these exponents lead to crop failure that creates famines and food prices to rise.

2.2.1 Land use change

Land use and systems changes. As temperature increases and rainfall amounts change and become more variable, the niches for different crops and grassland species change. Transitions from one crop to another, or between crops and rangelands, can occur. As temperate areas become warmer, substitution for crop species more suited for warmer climates may take place. In parts of East Africa, reductions in the length of growing period are likely to lead to maize being substituted by crop species more suited to drier environments such as sorghum and millet (Thornton et al., 2008b). In marginal arid places of southern Africa where crops grow, the reductions in length of growing period and the increased rainfall variability is driving systems to a conversion from a mixed crop-livestock system to a rangeland-based system, as farmers find growing crops too risky in those marginal environments (Masikati et al., 2014). These land-use changes can lead to different compositions of animal diets and to changes in the ability of smallholders to manage feed deficits in the dry season. These two effects can have substantial effects on animal productivity and on the maintenance of livestock assets.

2.2.2 Use of fertilizers

Increased emissions of Green House Gases are driven largely by fertilizer use, agricultural nitrogen fixation, and atmospheric nitrogen deposition. Livestock activities contribute substantially in two ways: in the use of manure and slurry as fertilizers, and through the use of fertilizers to produce feed crops. These account for about 65% of global anthropogenic emissions (75-80% of agricultural emissions). Emissions of Nitrous Oxide originating from animal manure are much higher than any other N_2O emission caused by the livestock sector, and these emissions are dominated by mixed crop-livestock systems (Steinfeld et al., 2006).

2.2.3 Quality of plant material

Increased temperatures increase lignification of plant tissues and therefore reduce the digestibility and rate of degradation of plant species (Minson, 1990). This leads to reduced nutrient availability for animals and ultimately to a reduction in livestock production, which may have impacts on food security and incomes through reductions in the production of milk and meat for smallholders. At the same time, the interactions between primary productivity and quality of grasslands will demand modifications in grazing systems management to attain production objectives. The impacts of increasing temperatures and CO_2 concentrations, together with shifting rainfall distributions and amounts, may play themselves out in complex ways in relation to feed resources.

2.3 Livestock production and climate change

Livestock need to be managed in ways that maintain vegetative groundcover, because vegetation loss may result in increased soil erosion, down-slope sedimentation, reduced infiltration, and reduced pasture production (Sheehy et al., 1996). Low to moderate grazing pressure may have little negative impact on hydrology, while at higher levels of grazing intensity, water and land degradation may become problematic and animal production decline. There are strong interactions between livestock grazing and animal drinking, via localized vegetation removal and trampling.

2.4 Relationship between climate change and land management

There is limited information on the link between climate change and land management. However, a study by (Thebault et al., 2014) on the Land management and effects of climate change and elevated CO_2 on grassland functioning found that, climate change and CO_2 can affect many ecosystems based functional attributes, it suggests that combinations of land management practices remain the dominant set of factors in determining the performance of grassland plant communities. Land management may thus be critical for influencing projected responses to future climate change and elevated CO_2 in models of grassland function at least for factors relating to primary production (Thebault et al., 2014).

According to the IPCC (2014), and broadly confirmed by more recent analysis of the IPCC datasets, (Tubiello et al., 2015) and Food and Agriculture Organization of the United Nations (FAO) data (Federici et al., 2015), net emissions from land-use changes represented ≈ 10-12% of total GHG emissions around the year 2005. Beyond the mitigation potential related to reducing emissions from land-use changes, the Land-use, Land-use Change and Forestry (LULUCF) sector also provides a relevant contribution through the conservation and enhancement of carbon sinks (e.g. cropland management, grazing land management, forest management, forest expansion) and through the provision of renewable energy and materials. Soil carbon stock is the largest potential sink, mitigating ~1.2 GtCO2e yr-1 in 2030 at USD 20/ tCO2e (Smith et al., 2014; Williamson, 2016), although its effects are easily reversed with intensive tillage or soil disturbance, and there are still important uncertainties about long-term stability of soil organic carbon and possible saturation effects (Sanz et al., 2017). Reducing the land-use change for the benefit of expanding agricultural lands worldwide has the potential to mitigate 1.71–4.31 Gt CO_2 yr^{-1} by 2030 (Carter et al., 2015). Historically, global land use and land use change factor emissions reduced between 1990 and 2010 according to (Grassi et al., 2017). These results are evident that land management significantly affects climate change.

2.5 Impacts of Climate Change on Livelihoods in Agro-Pastoral Communities

The impacts climatic conditions have had on agro-pastoralists some have been found to be irreversible most especially when they are not combated during their initial stages. These impacts cut across to both crops and livestock farmers.

2.5.1 Farmers perception on climate change

To design effective messages and strategies to support adaptation and mitigation efforts it is important to know whether communities that are being affected by climate change are aware of it and, if so, how they perceive it. Several lines of evidence from this ethnographic study suggest that African farmers are generally familiar with climate change and this awareness is distributed across groups and social categories Rather than being a topic that is restricted to a category of experts, specialists or leaders, climate change is introduced easily in conversation of farmers as they discuss climate forecasts and farm management plans.

Tiyo et al., (2015) assessed farmer perceptions of climate change in Agro-Ecological Zones Bordering National Parks of Uganda. According to their study, the small-scale farmers were aware of climate change events. The largest proportion of the respondents was affected by climate change effects with more impacts felt in Kapchesombe (highland agro-ecology) (Tiyo et al., 2015). Tiyo et al. 2015 also found that major coping strategies employed included: planting different crops, different planting dates, different crop varieties, soil conservation and crop diversification. According to them, climate change has led to food insecurity due to crop failure, soil erosion, shift in spread of diseases and land degradation in Agro-Ecological Zones Bordering National Parks of Uganda.

Similar results have been reported by (Kusakari. et al., 2014; Jiri et al., 2015; Mubaya et al., 2012) in Ghana and Zimbabwe. Many farmers have experienced the effect of climate change on their livelihoods activities (Kusakari. et al., 2014). Some of the reasons respondents gave to justify their perceptions departed from the ideas provided by conventional scientific researchers in upper west region of Ghana (Kusakari. et al., 2014). Their results showed that farmers perceived that there has been a decrease in annual rainfall and an increase in average temperatures (Mubaya et al., 2012). Farmers' adaptation options included adjusting planting dates and crop diversification. Off-farm income has reduced the dependence of the farmers on agriculture. They concluded that, farmers exhibit homogeneous perceptions on changes in climate, although they are diverse in their socio-economic attributes, which are consistent with observations of empirical climate data (Jiri et al., 2015).

Meteorological data analyzed confirmed the warming (Tiyo et al., 2015). The data also shows that farmers are particularly concerned with agronomic significant aspects of climate variability and change (for example, delayed onset of rains). Farmers concerns for climate change largely centered on precipitation, a crucial factor in this area, where rains are often insufficient for crops to germinate, mature and reach harvest. This is worth noting given that many models of climate change are more confident in their predictions for temperatures rather than rainfall, especially in Africa. This means that communication that emphasizes parameters such as temperature changes associated with global warming may be less effective in capturing farmers' attention and motivating them to respond positively (Roncoli et al., 2008).

2.5.2 The Climatic Change Adaptation Interventions

The vulnerability, coping and adaptive capacity and resilience of farmers to climate change and variability in semi-arid systems could be addressed through different adaptation strategies (Jiri et al., 2015). However, research has shown that farmers' adaption strategies largely depends on how they perceive climate change. A farmers' ability to perceive climate pre-empt to their choice to cope and adapt (Moyo et al., 2012; Kihupi et al., 2015). The coping and adaptation strategies of smallholder farmers depend, to a large extent, on their perception knowledge level (Kihupi et al., 2015). In essence, adaptation to climate change and variability requires farmers to first notice that the climate has changed, and then identify and implement potential useful adaptations (Adger et al., 2005). Consequently, without adaptation, the vulnerability of agro-based communal households would increase with climate variability and change.

Some of the adaptation strategies are: reversing land degradation through the adoption of sustainable agricultural land management (SALM) practices, managing heat stress on crops and animals, using crop varieties and management systems that do well under a broad range of soil and climatic conditions, promoting the efficient capture, storage and utilization of rainfall through the adoption of appropriate soil and water conservation practices, the provision of irrigation, and the use of systems and practices with high use efficiency, maintaining soil fertility and productivity by arresting nutrient mining and building or sustaining soil fertility and guarding against pest and disease pressure. These are activities, practices, strategies, and investments that specifically target risks associated with climate variability and climate change.

Most CCA interventions address short-term climate change variability such as seasonal or annual variations in temperatures and/ or rainfall and extreme events. Use of drought-tolerant crops or livestock breeds, water conservation strategies, irrigation systems and even flood mitigation structures all address short-term variability more than the potential impact of long-term changes in average temperature or rainfall. Access to climate information is a CCA intervention that explains the short-term focus: seasonal or annual forecasts of temperature and/or rainfall are more useful to smallholder farmers than modeling of predicted average temperature in the year 2050; long-term climate projections are of limited use in making informed decisions from year to year about what or when to plant or where to graze livestock.

The cattle corridor is characterized by increased scenarios of dry spells majorly due to desertification. The poor land management practices leading to desertification include; overgrazing, deforestation, poor farming practices and soil erosion (Kisamba-Mugerwa, 2001). Poverty coupled with a rapidly increasing population exacerbates these factors. This scenario has intensified land degradation resulting in losses to the productive potential of the land, leading to more frequent famines, lower household incomes, increased pastoral migration both within the cattle corridor (Kisamba-Mugerwa, 2001).This has led to changes in land use cover types such as expansion of cultivated lands in natural vegetation types (grasslands, bush land, wetland and woodland), expansion of grasslands into bush land and woodlands, introduction and expansion of pine plantations into woodlands, bush lands and grasslands, encroachment of bushes and woodlands into grasslands and increase in bare ground (Zziwa et al., 2012).The creation of new polices such as privatization of communal grazing land contributed to the degradation of the range lands in the cattle corridor. However, the impact of these development policies varies according to the aridity of the rangeland (Kisamba-Mugerwa., 2001).

2.5.2.1 Integration of crop and livestock system

(F. Bagamba et al., 2012) proposed a highly integrated crop and livestock production system based on dual purpose (both food and feed) sweet potato as an alternative to the current systems practiced in the rangeland setting. Sweet potato production is suited to smallholder agricultural production systems because of its high productivity and low input requirements (Claessens et al., 2009). According to (Claessens et al., 2009), incorporating dual purpose sweet potato vines in animal feeds increases the feed quality in terms of crude protein and thus causes increase in milk production.

2.5.2.2 Diversification

Diversification may be of different types. Agricultural diversification occurs when more species, plant varieties or animal breeds are added to a given farm or farming community, and this may include landscape diversification – different crops and cropping systems interspersed in space and time. Livelihood diversification may occur when farming households are involved in more and different (non-agricultural) activities, for instance by taking up a job in the city, setting up a shop, or by starting to process farm products, (Phillip K Thornton & Mario Herrero, 2014)

While diversification can be an important element of climate change adaptation, there is surprisingly limited information available that can be used to guide farmers and farming communities as to how best to manage diversification possibilities. What works in particular situations is highly dependent on the geographical and socio-economic context of the specific farming system. The addition of trees to the farming system may be able to provide smallholders with a broader set of options for securing both food and income (Sunderland, 2000).

2.5.2.3 Pasture conservation

One of the major GHG emission contributions from livestock production is from forage or feed crop production and related land use. Proper pasture management through rotational grazing would be the most cost-effective way to mitigate GHG emissions from feed crop production. Animal grazing on pasture also helps reduce emissions attributable to animal manure storage. Introducing grass species and legumes into grazing lands can enhance carbon storage in soils. Grazing intensity should be properly regulated to enhance carbon sequestration. It is important to note that methane emissions, grazing intensity and increase in woodland cover are all interrelated issues. Overgrazing of rangelands has led to the degradation of water resources, soil structure, and plant communities in the Pacific Northwest (Charnley et al., 2018). Thus, conserving the remaining high-quality and high-functioning rangelands across the region is a critical first step in supporting productive livestock operations. In addition, studies show that conserving biodiversity on landscapes helps in building landscape resilience to climate change (Janowiak et al., 2016). Natural plant diversity across rangelands minimizes the risk of catastrophic events (wildfire, disease, and pests) and improves consistency of livestock production (Provenza., 2008). In addition, supporting the health of native forb species is vital to maintaining biodiversity (Briske et al., 2017).

2.5.2.4 Drought tolerant pastures

Planting novel drought and heat tolerant grasses for example, Lolium multiflorum or Lolium perenne ensures that the foliage is present all year round. It also enhances soil water storage capacity and limit runoff, decrease in N2O emissions and increased soil C storage, ensure ecological stability (Macleod et al., 2013; Volaire et al., 2014)

2.5.2.5 Irrigation

This is also a crucial asset, especially for pastoralists who are vulnerable to frequent and prolonged drought and where there is increasing climate variability. Therefore, households having access to irrigation water can have the opportunity to diversify their livelihood strategies and easily adapt to climate-induced shocks.

2.5.2.6 Water conservation

Protecting and preserving high-quality watersheds is easier and generally more successful than to trying and recreate or restore degraded habitat (Roni, 2002). Healthy watershed ecosystems support many essential ecosystem services including: enhancing biodiversity, enhancing soil health, improving water quality, encouraging pollinator habitat, controlling erosion, providing essential water. services for rangeland production, sequestering carbon, and reducing the susceptibility of individual ecosystem components to climate change (Janowiak, 2016). In order for watersheds to effectively capture, absorb, hold, and use water necessary for effective livestock production, riparian areas must be in good health (Bellows, 2003). Introduction of simple techniques for localized irrigation (for example, drip and sprinkler irrigation), accompanied by infrastructure to harvest and store rainwater, such as tanks connected to the roofs of houses and small surface and underground dams.

2.5.2.7 De-stocking

In the absence of productivity-enhancing mitigation strategies (for example, dietary oils), this will tend to reduce overall farm productivity. If currently overstocked, this strategy ensure that the available pasture resources are enough for the available stock thus can reduce degradation risk and improve the natural resource base. Lower stocking rate can increase carbon stocks in many grazing systems but also reduce them in some South American systems (De Oliveira Silva et al., 2016). Emissions per unit land area are likely to fall. In some particular tropical livestock systems, lower stocking rates and lower pasture inputs can reduce soil carbon stocks, reducing whole-of-system emissions efficiency.

2.5.2.8 Herd splitting

The households in Nyangatom further practice herd splitting: they give part of their stock to relatives and friends who are trustworthy and have access to better pasture and water. This traditional practice is not only implemented to deal with drier conditions during Akamu but also to escape from (potential) conflict-related damage. Similar studies indicate that herd splitting and diversification are an essential component of agro-pastoralists' coping strategies (Zampaligre et al., 2014; Opiyo et al., 2015).

2.5.2.9 Supplementary feeding

Grains and other feed supplements such as molasses can reduce methane yields and enhance production. If used strategically, can protect the above and below ground C stores (Thornton and Herrero., 2014). Adaptations through Animal Feeding Enhancement in nutritional value of animal intake and breeding for heat-resistant animals can be key strategies to maintain and improve the productivity and welfare of livestock. Das et al., (2016) have identified a range of nutritional strategies to cope with high temperatures. These are animal diets with high energy to recover decline in quantity of feed and higher energy demand for thermoregulation, addition of a low rumen degradability protein to compensate for increased N catabolism. Also, this can include increase in frequency and time of feeding, and addition of supplements to meals for example, whole flaxseed to enhance immune function and productivity.

2.5.2.10 Migration

Migration can be a proactive adaptation strategy, particularly at early stages of environmental degradation. It can also be an effective disaster risk reduction strategy. (IOM, 2017). However, poorly managed migration flows can lead to increased vulnerability to climate risks; heightened pressure on scarce natural resources thus affecting pasture availability in occupied places. Additionally, Long distance migration across international borders when undertaken on inadequate information can have serious consequences for the pastoralists. A classic example is when the group, hoping to find water along its route, attempts the long journey only to find on arrival that the water source has dried up, or the borehole engine has broken down or even has been vandalized.

2.6 Climate Change Mitigation Strategies in Agro-Pastoral Systems

A number of mitigation strategies were put across by agro-pastoralists in the communities.

2.6.1 Climate change mitigation measures

According to (Recha et al., 2014) Climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects that reduces harm or exploits beneficial opportunities. Adaptive capacity to climate change is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Recha et al., 2014). More robust adaptation plans are required to manage the additional risk for communities that are exposed to unexpected or unforeseen changes in weather patterns and increased risk.

The fact is that climate change has occurred, is occurring and may continue to occur, and its occurrence threatens the very essence of human existence (Denton., 2009). Some of the effects of climate change can be mitigated, while others will be unavoidable in this century, regardless of efforts to reduce greenhouse gas emissions. Nevertheless, the magnitude of the problems caused by climate change is so enormous that it is projected that by 2080 600 million people worldwide will suffer from malnutrition as a result of climate change (Denton F., 2009).

Climate change mitigation involves reducing the amount of greenhouse gases in the atmosphere or enhancing their sinks, for example, by reducing the use of fossil fuels, planting trees, or enhancing mineralization of organic matter into soil organic carbon (Recha et al., 2014). Strategies for reducing greenhouse gas emissions include sustainable land management practices like: soil nutrient management, tillage and residue management, agronomic practice agroforestry, soil and water conservation, and improved livestock management (Recha et al., 2014).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area description

3.1.1 Location

Nabiswera sub-county is located in the eastern side of L. Kyoga, in the central region of Uganda, Nakasongola district, within the latitude $1^0$27'36" North and longitude $32^0$15'53" East. The sub-county headquarters are located in about 5km off Kampala-Gulu highway, branching off from Migyera trading center heading Eastwards.

3.1.2 Climate of study area

Nakasongola district is one of the driest districts in Uganda, characterized with prolonged drought episodes, scattered woody biomass plant communities and Savannah (David et al., 2017). The district is located in the north-western part of the central region of Uganda (Roothaert and Magado,2011), and it is 115 km from the National capital, Kampala. The district has 9 sub-counties namely; Kalungi, Kakooge, Lwampanga, Nabisweera, Wabinyonyi, Nakitoma, Lwabyata, Kalongo and Nakasongola Town Council. It experiences a bimodal type of rainfall with the first rain season occurring from March/April to June/July and second season occurring from August to October/November of each calendar year, (David et al., 2017). The amount of rainfall received ranges between 500 to 1000 mm per annum. The maximum daytime temperature ranges between 25 to 35°C, while the minimum diurnal range is 18 to 25°C and the potential evapotranspiration remains high through the year (~130 mm/month and ~1586 mm/annum) and shows less variability unlike the rainfall. The soil catena is composed of Buruli and Lwampanga; occurring in both undulating areas and valleys (Mugerwa et al., 2011).

3.1.3 Land use and economic activity

The Sub-county consists of six (6) parishes which include; Mulonzi, Katuba, Kyangogolo, Kyamukonda, Migyera and Kalengedde, (Figure 1). This study is focused on 3 parishes, that is Migyera, Kyamukonda and Kyangogolo. The farmers in the area mainly depend on annual crops production like Maize, beans, sweat potatoes, cassava, for example, while the rest deal in livestock farming especially those with large chunks of land, as well as mixed farming as a common practice. Non-farming activities like charcoal burning, and fishing for those near Lake Kyoga.

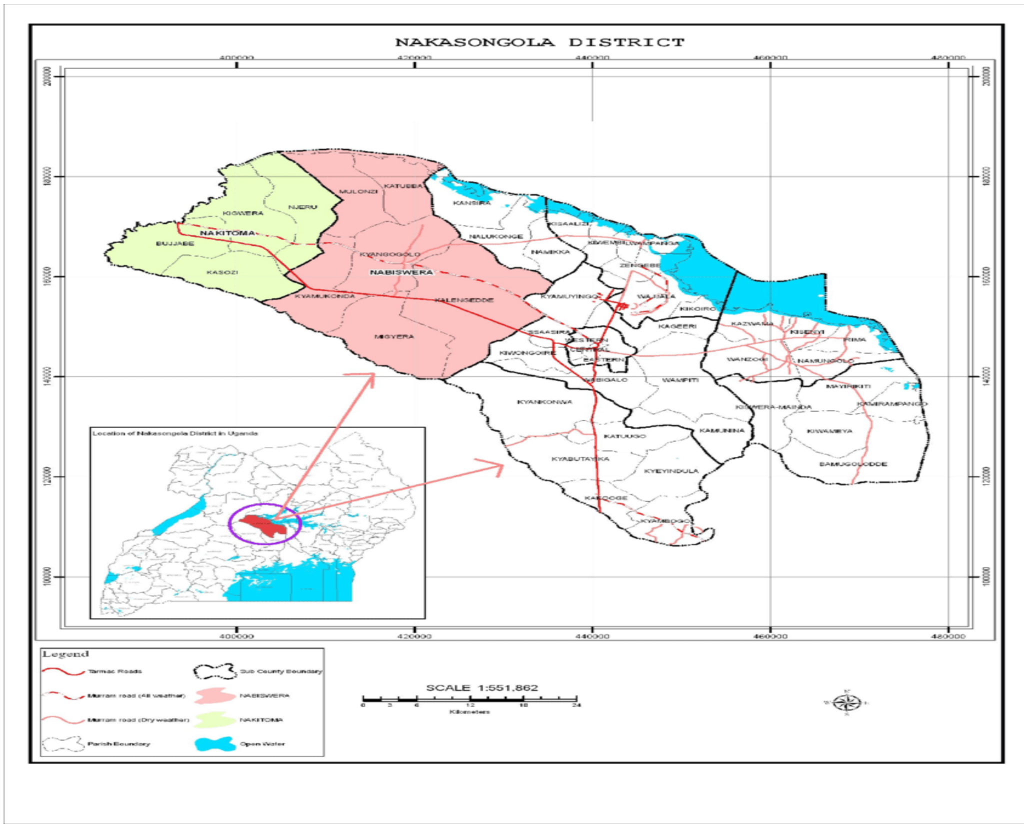

Figure 1: Location of Nabiswera Sub County Nakasongola district

3.2 Research design and data collection

A cross-sectional survey method was used where both quantitative and qualitative research approaches were used during the study. Qualitative data was collected using a structured questionnaire. The questionnaire developed for study consisted of a combination of open and close ended questions which were used to obtain specific information from farmers. The questionnaire was used to inquire about farmers' demographic and farm characteristics, and as well as assessing the farmers' knowledge, attitude and perception about Climate Change. Adaptation measures being used in their communities. The questionnaire was pre-tested and revised to ensure that the questions were clear and could be comprehended and understood by the farmers. A total of 43 farmers were interviewed and these were selected randomly and purposively considering only those who had stayed in the area for over 20 years. These were obtained by help of agricultural officers' lists where farmers had registered.

Primary data was obtained through interviews with selected respondents. The interviews with farmers employed a natural flow of conversation and discussion of each farmers' experiences. The qualitative data was obtained through KIIs using a Key Informant Interview Guide and the key informants were purposively selected and they included the regional agricultural and sub-county extension officers. The following indicators were used to measures the effectiveness of a given Climatic Change Adaptation Intervention: increased soil fertility, reduced soil erosion, increased crop/ animal yields, increased pasture biomass, sustainable production, increased water availability and increased income. Each indicator was scored using ranks from 1-5 where 1 was the lowest score while 5 the high score. The Multi-Criteria Analysis tool was used to collect data through the steps bellow;

3.2.1 Identify the most common climate shocks

During the discussions of climate shocks in the FGDs an MCA was conducted. While carrying out an MCA, only two of the most significant climate shocks were selected so that the participants remain engaged and this was done purposely for an MCA not to deteriorate into a mechanical exercise of weighting and scoring. In some cases, certain shocks were combined basing on their description by the community. For instance, community members identified drought and high temperatures as two shocks. Through follow up discussions, participants concluded that these two events tend to occur together and should be combined as a single shock, drought. Using PRA tools, we were able to identify a broad range of climate-related shocks, how people experience them, and the impacts on different social groups. MCA was then used to aggregate and refine the qualitative data to identify priorities for CCA interventions

3.2.2 Identify the Climate Change Adaptation Interventions

Different farmers pointed out a number of different Climate Intervention measures, with further inquiries, participants identified some of the most effective adaptation interventions for managing the respective shocks. These interventions were then noted for the later further analysis and explanations.

3.2.3 Identify the decision-making criteria

Tactically, the farmers were guided on the criteria that they could follow to come up with most appropriate adaptation measures. Basing on their experiences and the results they have achieved in previous adaptions applied, farmers were guided the ways they could handle the harsh Climate conditions.

3.2.4 Rate the performance of the Climate Change Adaptation Interventions

After developing the criteria to be followed, the effectiveness of the adaptation measures was rated against the criteria. The illustrative matrix was used to guide the discussion and recording the scores. The Table below offers an illustrative example; the complete template is also included. The matrix was completed using data collected in steps 1 to 3. Specify the climate shock, the CCA interventions (rows 1-7), and the criteria (columns A to E). Then, the scores were recorded. Making sure that the scale is consistent for every MCA exercise conducted during fieldwork. Then, for each CCA option, participants were asked to assign a value (1-5) of importance or effectiveness in relation to each criterion. A scale of 1-5 was used to score each option, where 5 represents excellent, 4= high, 3= medium, 2= very and 1= low.

Table 1:Scoring matrix

CRITERIA	A	B	C	D	E
Parameters	Community benefits	Life-saving, humans and animals	Protects land	Multi-purpose	Tested and proven
Climatic Change Adaptation Interventions		**SCORING OF CRITERIA**			
1. Savings	5	5	3	5	4
2. Water harvesting	5	5	3	5	5
3. Livelihood diversification/ IGAs	5	5	1	5	5
4. Improved seeds	3	5	3	4	5
5. Reforestation	5	5	4	5	5
6. Information for decision making	4	3	4	4	3
7. Fuel efficient stoves	4	3	1	3	3

3.2.5 Assign weights to the criteria

Assigning weights to different criteria was done by the help of farmers based on the criteria level of importance. All weigh had to add up to 100 across the criteria.

3.2.6 Rank the selected Climate Change Adaptation interventions

This step is part of the analysis phase of MCA, carried out after the fieldwork. Scores and weights recorded on matrix forms were transferred into excel sheets. After scores were entered for each CCA option under each criterion, the excel template automatically calculated a total weighted score for each option by multiplying each score with the weight of the respective criterion. Notes recorded on the decision-making process were entered into FGD data collection matrices.

3.3 Data analysis management

Data management from survey questionnaires was carried out using SPSS software program for Windows, version 21 (SPSS Inc., Chicago, Illinois, USA). Frequencies and means were the major statistical tools that were used to enable the description of farmers' perceptions on changes in climate variables and plant health as well as the coping strategies being practiced to mitigate the effects of a changing climate. In addition, to analyze the production constraints faced by the farmers, a list of challenges researched from the literature were included in the questionnaire. Farmers were asked to rank the challenges in the order of importance as it affected them. The rankings provided were quantified through the application of the Garrett's ranking technique formula:

$$\text{Percentage Position} = \frac{100\left(R_{ij} - 0.5\right)}{N_j}$$

where Rij is the rank given to ith factor by the jth farmer and Nj is the number of factors ranked by the jth farmer. The calculated percentage position of each rank was then converted into scores by referring to the table given by Garrett and Woodworth (1969). The study regarded the first five constraints with the highest scores as the most pressing issues facing the farmers.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Demographic and Social Characteristics

The percentage number of the respondents were (60.5%) males and (39.5%) females; the largest percentage of the households interviewed had lived in the area for over 30years (55.8%), those who have lived between 26 to 30years were (16.3%) and the rest were between 10 to 25years (27.9%), most of the families were headed by men with (62.8%) and (37.2%) being headed by women., (23.3%) of the respondents had no formal education, (41.9%) had not completed primary level, (11.6%) completed primary level only, (14.0%) had done ordinary level while (9.3%) had attained higher education (Table 2).

Table 2: Demographic and Social Characteristics

Parameters		**Frequencies**	**Percent**
Gender of household head	Male	27	62.8
	Female	16	37.2
	Total	43	100.0
Gender of respondent	Male	26	60.5
	Female	17	39.5
	Total	43	100.0
Education level of respondent	No formal education	10	23.3
	Incomplete primary education	18	41.9
	Complete primary education	5	11.6
	O-level	6	14.0
	Above O-level	4	9.3
	Total	43	100.0
Years respondent/household has stayed in this village	10-25 years	12	27.9
	26-30 years	7	16.3
	Over 30 years	24	55.8
	Total	43	100.0

The farmers interviewed were selected from two sub-counties; Nabiswera and Migyera as newly formed town council which was formally a parish in Nabiswera Sub-county, in Nabiswera sub-county only two parishes were selected that is Kyangogolo and Kyamukonda and these constituted for 14 and 12 people respectively of the total farmers who were interviewed. (17 people) were selected from Migyera town council as shown in (Table 3) below.

Table 3: The number of farmers that interviewed from different sub-counties

Parish	Sub-counties			
	Nabiswera		Migyera T/C	
	Frequencies	Percent	Frequencies	Percent
Kyangogolo	14	53.8	0	0.0
Migyera central ward	0	0.0	17	100.0
Kyamukonda	12	46.2	0	0.0
Total	26	100.0	17	100.0

Analysis showed that most farmers owned land on average 56.87 acres with the minimum of one acre and maximum of 320 acres of land. It was found out that pastoralists owned the largest chunks of land whereas the crop farmers having small acres for farming and settlements. Mostly farmers owned land under leasehold system (55.8%) while (30.2%) reported to have Mailo land system of land ownership and those who had communal land ownership contributed for (11.6%) with the other (2.3%) under customary land ownership system.

Table 4: The system of land ownership, the average size of the piece of land and the minimum and maximum piece of land owned by farmers

System	Frequencies	Percent	Mean	Minimum	Maximum
Mailo land	13	30.2			
Customary	1	2.3			
Leasehold	24	55.8			
Communal land	5	11.6			
Acreage of parcel			56.87	1.00	320.00

4.2 Land allocation to different enterprises in early 2000 and currently

After analyzing data, the land allocation to different enterprises is found to have reduced greatly, whereas grazing used to be carried out on the average of 610.9 acres of land, it's now carried out on the average of 53.2 acres. The current average land allocation for non-ruminants was 3.21 acres which was formerly 11.25 acres in the early 2000 (Table 5).

However, there was a slight change in acreage in growing of annual crops from 5.97 acres in early 2000 to 4.49 acres currently, and this was partly because the most households depend on annual crops mainly for their survival as wells as concentrating mainly on annual crops leaving the perennials. This maybe the reason as to why perennial crops have greatly reduced in acreage currently from 4.21 acres in early 2000 to 1.78 acres. Apiculture was never the enterprise that farmers used to practice in early 2000, yet currently the average of 2.00 acres have been partitioned for it. Furrow lands were not there in early 2000 whereas currently have been developed with the average acreage of 1.50 acres. More farmers have been found to grow more oranges and mangoes whereby agroforestry has been seen to increase from 0.04 acres in early 2000 to 0.97 acres currently. The respondents also reported that woodlands and natural forests were the dominant in the community with about an average of 85.38 acres in early 2000 and they have since reduced sharply to 9.64 acres currently, mainly due to deforestation for majorly charcoal burning, crop farming and settlements. The originally occupied areas with woodlands cover have been replaced with bushes and shrubs which were very few in the early 2000 on estimated 8.50 acres to where they have increased to 20.36 acres currently. The degraded/ abandoned lands were nowhere in the early 2000s.

Table 5: Land Allocation to different enterprises

Enterprises	Acreage in early 2000	Acreage Currently
Grazing (ruminant production)	610.94	53.22
Non-ruminant production	11.25	3.21
Annual crops	5.97	4.49
Perennial crops	4.21	1.78
Apiculture	0.00	2.00
Agro-forestry	0.04	0.97
Furrowed land	0.00	1.50
Bushes and shrubs	8.50	20.36
Forests/woodlands (Natural)	85.38	9.64
Degraded/abandoned	0.00	5.48

Planted Trees/ Forests	0.22	12.44

4.3 The grazing management system for ruminants

When the agro-pastoralists were interviewed regarding the types of grazing systems they were using, it turned out that (48.8%) practiced tethering due to shortage of land thus rearing small number of livestock like cows, goats and sheep in a controlled manner alongside crop growing. Farmers who happened to own big chunks of land practiced extensive grazing (37.2%) on their privately fenced farms. There were four farmers (9.3%) who reported about doing both tethering and extensive grazing systems. And other 2 farmers were involved in communal grazing with nobody involved in extensive grazing on improved pastures (Table 6)

Table 6: The grazing Management systems for Ruminants

Grazing systems	Frequency	Percent
Extensive grazing on natural pastures (privately fenced)	16	37.2
Extensive grazing on improved pastures (privately fenced)	0	0.0
Communal grazing	2	4.7
Tethering	21	48.8
Tethering & Extensive grazing on natural pastures (privately fenced)	4	9.3

4.4 The average number of livestock owned between now and early 2000

In order to determine the number of ruminants and non-ruminants kept on the farms, the selected farmers were asked about the number of cattle, sheep, goats, pigs and poultry kept on their farms for both currently and early 2000 as this was Important to give a clearer picture of the root cause of accelerated climate change in the area. The analysis showed that the mean number of cattle kept in the early 2000 was 133 heads of cattle which has declined with time to 34 heads of cattle and this was mainly due to severe drought and land shortages which has led to many reducing cattle to a managed number while others have died greatly lowering the cattle numbers. Cattle rearing was reported to be the highest source of income with a mean rank of 1.1 and the highest food source with mean rank of 1.2, because farmers reported that cows would provide milk for them daily for either selling as source of daily income or home consumption as food. The mean number of goats reared currently was reported to be 27 goats which has been noticed to have declined from 50 goats in early 2000. After analyzing, goats were found with a mean rank 1.9 both in terms of economic importance and food security. This ranked the goats third after cattle and pigs in the 1st and 2nd positions respectively, pigs had a mean rank of 1.7 bin terms of food security as many are reared mainly for family consumption than they're for selling (economic importance 1.8). There has been decline in the mean number of pigs reared from 23 pigs in early 2000 to 6 pigs which was mainly attributed to selling them to meet the home requirements during severe drought that causes poverty and hunger.

Farmers rearing sheep did not attach much importance to them due their low demand thus being with a mean rank of 3.0 and 3.1 both in terms of economic importance and food security. The mean number of sheep reared in early 2000 was estimated to be 14 sheep and has slightly reduced to 13 sheep currently, the sheep were ranked 4th among animals reared in the community in terms of economic importance (3.1) and in terms of food security (1.2). poultry reared in the parishes where farmers were interviewed found to have reduced to an average number of 16 chicken from 38 chicken in the early 2000. This reduction was attributed to partly because of theft in the area, disease outbreaks and selling them off to meet family needs.

Table 7 : Livestock numbers owned in early 2000 and currently

Live-stock types	**Number of animals in early 2000**	**Currently owned**	**Rank (in terms of economic importance)**	**Rank (in terms of food security)**
Cattle	133.0	34.3	1.1	1.2
Sheep	13.9	12.7	3.1	3.0
Goats	50.2	27.6	1.9	1.9
Pigs	23.6	5.7	1.8	1.7
Poultry	38.3	16.0	5.0	3.5

4.4.1 Reasons for changes in livestock types and numbers kept between 2000 and 2022

Further inquiry was made regarding why farmers had reduced greatly their animals kept in early 2000s as compared to the current numbers, and from the original indigenous animals to cross breeds in the recent years. They pointed out to a number of reasons and challenges which included; frequent drought which happened to be the main reason (97.6%) which has left community people without water and pastures leading to the death of their animals and crops grown. Shortage of land (92.7%) was another serious challenge that forced many to reduce their livestock numbers and switched to high productive ones. Land shortage has been mainly brought about by fast population growth both internally and the immigrants leaving people with few acres of land as compared to the large chunks they had in the early 2000. The other factors cited were water scarcity and pastures (95.1%) during severe drought, changes in production goals from more animals to high producing animals which are of exotic from indigenous breeds (Table 8). Increased incidences of pests and diseases (70.7%) which also happened to have killed most of the newly introduced cross breeds due to lack of effective disease control drugs and accaricides for tick control.

Table 8: Reasons for Changes in Livestock types

Reasons	Frequencies	Percent	Mean Ranks
Changes in land ownership from communal to individual	21	51.2	5.8
Shortage of land	38	92.7	2.6
Changes in production goals from more animals to high producing animals	25	61.0	6.8
Changes in animal breeds from indigenous to exotics and crosses	26	63.4	7.6
Increased pasture scarcity	39	95.1	3.2
Increased water scarcity	39	95.1	2.2
Lack of government subsidies to livestock producers	20	48.8	7.7
Frequent droughts	40	97.6	3.0
Unpredictability of seasons	25	61.0	5.7
Increased incidences of pests and diseases	29	70.7	8.9
Government policies	19	46.3	9.2

4.5 Major crops grown in early 2000 and currently including their average level of economic importance and food security

Most farmers were cassava growers (91%) and the other large number of farmers were sweet potatoes growers (70%) as an annual crop that takes less time about 3 to 4 months to mature and sustain their families in both good and harsh climatic conditions. The mean number of farmers growing cassava has with time increased from 1.2 acres in early 2000 to 1.6 acres currently in 2022, this was mainly explained as cassava varieties that can take less and more than a year were introduced and they are resistant to harsh conditions like drought especially the early maturing cassava varieties and when cassava does not have market it can be left in the gardens until the period of its demand. Whereas sweet potato growers have decreased in the acreage for other crops right the mean acreage of 2.9 acres in early 2000 to 1 acre in 2022. This was attributed to the fact that sweet potatoes have more disease outbreaks and they don’t last for months in the fields when they reach their harvesting period. Therefore, once sweet potatoes don’t get the market a few bags are harvested and dried and the rest are left to rot in the gardens. However, when farmers were interviewed to rank the crops grown in their level of importance, maize was ranked the most important economically with 1.8 and in terms of food security 1.6 mean ranks. Further analysis showed cassava to be the 2nd important economically (1.8) and (1.9) mean ranks, while the mean rank of sweet potatoes was 2.6 in terms of economic importance and 2.7 for food security. Other crops farmers grow are mainly annual and for sauce for example beans (0.5 acres in early 2000 and 0.7 acres in 2022), ground nuts (2.7 acres in early 2000 and 0.7 acres in 2022). While those who reported to be growing millet were only two farmers who have kept on reducing the acreage from 10 acres in early 2000 to 1 acre in 2022, reasoning that millet has less demand and its grown purposely for local brewing.

Table 9: Crops grown in early 2000 and in 2022 with their economic importance and food security

Crops grown	Frequencies	Percent	Average acreage 2000	acreage 2022	Mean Rank for economic importance	Mean Rank for food security
Bananas	14	33	1.4	0.9	3.8	3.8
Maize	26	60	1.5	2.5	1.8	1.6
Sweet potatoes	30	70	2.9	1	2.6	2.7
Cassava	39	91	1.2	1.6	1.8	1.9
Groundnuts	14	33	2.7	0.7	3.3	3.1
Beans	22	51	0.5	0.7	3.7	3.5
Millet	2	5	10	1	2.0	2.0
Others	3	7	0.4	1	1.3	3.8

4.5.1 Reasons for changes in crops grown and acreage in the previous and current years

There has been a change in the crops grown between early 2000 and currently in 2022 by either increase in the acreage for some crops or reduction in acreage for other crops but mainly there has been reduction in the most of the crops especially the perennial crops like banana plantations where you can hardly find a household practicing them on a large scale like how it used to be in early 2000, when farmers were interviewed on what could have caused all these changes mostly (88.4%) mentioned drought to be the major reason for reduction in the crops grown. Where drought most especially affects the perennial crops more so if they are not drought resistant varieties. Other challenges that led to the reduction in production in food crops included shortage of land which was mentioned by (81.4%) of the farmers,

Table 10: Reasons for changes in Acreage for the crops grown in early 2000 and currently

Reasons	Frequencies	Percent	Mean Ranks
Changes in markets	15	34.9	8.9
Shortage of land	35	81.4	2.3
Need to diversity in come	32	74.4	4.6
Declining soil fertility	21	48.8	5.2
Need to produce own food	30	69.8	2.9
Changes in seasons	32	74.4	3.8
Unpredictability of seasons	26	60.5	5.0
Increased incidences of pests and diseases	25	58.1	5.4
Frequent droughts	38	88.4	2.0
Government policies	16	37.2	8.7

Table 11: Major Challenges to Agricultural Production in the area

Major challenges to agricultural production	Frequencies	Percent
Prolonged drought	40	93
Pests & diseases	23	53
Termites destruction of gardens	20	47
Soil infertility	15	35
Fluctuations in prices	11	26
Land shortage	11	26
Water shortage	11	26
Lack of pasture	7	16
Crops destroyed by animals	6	14
Thieves	5	12
Lack of extension services	4	9
Bush invasion	2	5
High prices of improved varieties	2	5
Poverty	1	2
Lack of access to extension services	1	2
Hard soils	1	2
Increased hooking invasive species	1	2
Death of animals	1	2

Most of the farmers (93%) reported that prolonged drought has been the biggest challenge in their agricultural production which has led to scarcity of water for both domestic and animal use, with lack of pastures as reported by pastoralists. During this season of drought agricultural production is put to a standstill thus resulting to food scarcity and severe poverty amongst different homesteads. Pests and diseases (53%) becomes very rampant in the dry season and another serious challenge as the farmers are lacking the preventive measures. Termites invasion (47%) which is exacerbated by prolonged drought where termites destroy both crops and pastures causing failure in agricultural production.

4.6 Farmers knowledge, attitude, and perception on climate change

When farmers were asked whether the experienced changes in climate change parameters have affected agricultural production and livelihoods, all of them (100%) responded positively. Direct observations made during the data collection show that the short rainy season (March, April and May), that is used for cultivation of some crops had elapsed without any cultivation activity. In some areas, attempts made by farmers to cultivate within the short rains were unsuccessful and farms with dried-up maize, sorghum and potato were seen everywhere due to the rains that began earlier than the expected time and ended immediately after sowing and first weeding of the young crop. Even in those farms that survived the extended drought, crops appeared physiologically less vigorous. As a result, the productivity of major crops had been declining progressively over the last two decades. The impacts cited by most farmers (91%) were annual crops failure due to drought that started earlier in the season than usual. While (58%) of the farmers reported low crop yields and the rest (2%) said there was an outbreak of diseases especially in the sweet potatoes. Same impacts were reported from the farmers who grow annual crops where they experienced severe drought leading to loss of all the crops grown. Low milk production and death of livestock were the leading impacts (63%) amongst the livestock farmers which were brought about by persistent drought in the community (Table 13) below. Other farmers reported about disease outbreaks, poor calf growth and ticks which they claimed to be caused by climate change impacts.

Decline in soil fertility and drying of soils were the major impacts climate changes had on the soils as reported by (30%) of the farmers. Other impacts included soil erosion (23%) and development hard pans (16%). The major cause of erosion was due to wind blowing over dry soils with no any vegetation cover which accounted for (86%) of the farmers who identified it as an impact of climate change especially in the dry season along with increased leaf fall as a way of minimising water loss from plants.

The impacts identified on water resources include; drying of water dams (63%), contamination of water bodies (49%) and sedimentation of dams (21%) as shown in (figure 4). The contamination and sedimentation of water bodies was mainly due to run off of water depositing all the rubbish (dead plant materials) and soils into the water dams. This is observed in the first rains of the season which find the soils very weak after a severe drought. Increase in invasive species like some unpalatable pasture species (44%) of the farmers reported about this impact while there were also increase in hooky bushes (33%) invading up the grazing area at a very high rate due to increased incidences of droughts. Farmers also identified some impacts of climate change on pasture production and palatability as loss of palatable as a major one (77%), increase in hooky bushes (5%) which easily out compete the pastures in dry season because animals are feeding on pastures with less or without rains which makes their rejuvenation slow resulting into their extinction. Only two farmers (5%) complained about termites' destruction of pastures that they are more rampant during dry seasons due to lack of plant materials to feed on and they resort to standing hay in the farms. Diseases outbreak like flu and coughs were the major health impacts due to climate change reported to out spread in the communities especially in the dry season caused by mainly dust carried by wind as people inhale it. Only farmer reported about malnutrition (1%) especially in children due to lack of food in dry season.

Table 12: Farmer's responses in relation to Impacts of Climate Change on the agricultural produces and other parameters.

Parameters	Climatic impacts	Frequencies	Percentages
Annual crops	Low yields	25	58
	Pests and diseases	1	2
	Crop failure	39	91
	Termites	2	5
Perennial crops	Low yields	15	35
	Pests and diseases	1	2
	Crop failure	13	30
Livestock	Stunted growth	4	9
	Low milk production	27	63
	Disease outbreak	4	9
	Death of livestock	27	63
	Ticks	2	5
Soils	Development of hard pans	7	16
	Drying of soils	13	30
	Decline in soil fertility	13	30
	Soil erosion	10	23
Water resources	Contamination	21	49
	Drying of water sources	27	63
	Sedimentation of dams	9	21
Vegetation	Loss of vegetation	37	86
	Dropping of leaves	4	9
Invasive species	Bushes & shrubs	1	2
	Increased unpalatable SPP	19	44
	Increased hooky bushes	10	23
Pasture production & bio-diversity	Loss of palatable pasture	33	77
	Increase in hooky bushes	2	5
	Termites	2	5

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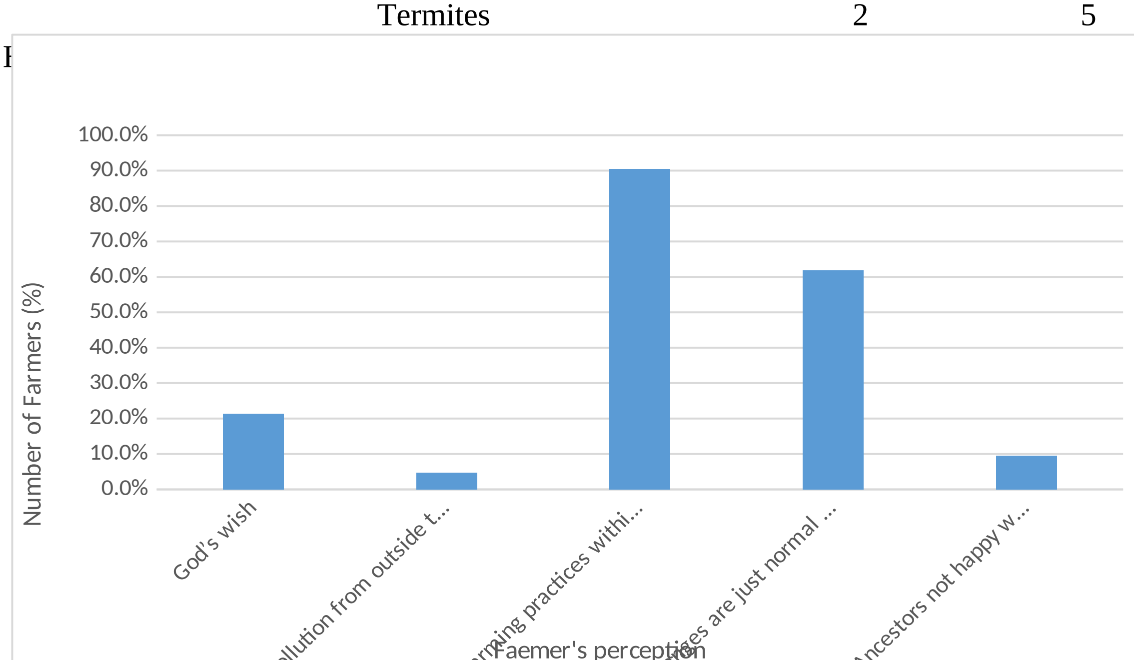

Figure 2: Farmers Perception on the major causes of Climate Change

4.6.1 The Farmers' Perception on the major drivers of climate change

Out of all farmers interviewed, the highest percentage (90.5%) suggested that climate change in their area was mainly caused by human practices carried out in their communities. The identified practices included deforestation for mainly charcoal burning and cultivation, overgrazing, as the main cause. (61.9%) of the interviewed farmers in the sub-county believed that changes were just normal and expected, therefore human practices might have not had any impact on the climate change. Those who perceived that it was God's wish to have a change in the climate conditions were (21.4%) and (9.5%) reported that ancestors were not happy with them. Only (4.8%) identified pollution outside the community as the cause of climate change resulting from poor disposal of the town wastes due to a fast increasing population without an organized way of waste management.

4.6.2 Knowledge on the most affected age/ gender category of people by climate change

In order to determine the age/gender category and group which mostly experiences hardships during harsh climate conditions, farmers who were interviewed reported that men are mostly affected due to the fact that they are burdened to look after the family by providing for it the basic needs like food, clothes, medications, school fees, which overwhelm them because the main source which is agricultural production is momentarily closed in severe dry season and the other hoped for sources bring in far less income to meet the family needs. Women were mainly affected due to lack of water (36.6%) and high temperatures (4.9%) which paralyse the rest of the farm and household activities leading to severe poverty (14.6%), lack of food (24.4%) and firewood (19.5%).

Some of the coping mechanisms applied by women were use of boreholes and dams (30.6%), charcoal burning (22.2%) and eating less meals (16.7%) per day. Farmers reported that the youths were affected in terms of lacking tuition to take on higher education or technical trainings and lack of jobs to sustain themselves at school and in the community for their basic needs. The ways of coping up with the challenges were working with the elders in brick laying activities for some small pay and also their parents selling off some animals like goats and cows to meet their school fees needs. The most noted challenge of climate change effect on children was lack of enough food varieties (41.4%) that led to malnutrition. Consistent disease outbreak (37.9%) like flu and cough due to the dusty air they inhale on the dusty roads in dry season. Walking under harsh sunshine to school and while fetching water and firewood.

Some of the coping ways to such challenges that children face in the dry season were going to school very early in the morning, giving them local herbs or seeking medical attention from government hospitals in case of disease outbreak, eating less meals but supplemented with protein rich foods like milk and eggs, and selling off some animals like poultry, goats and cows to meet their school fees requirements.

4.7 Common Climate Shocks in Nabiswera Sub-county

The highest number of farmers in the area acknowledged to be aware of the climate changes in the area, and they have responded with different adaptation measures for survival means.

Table 13: Farmer's perception on changes of different climatic parameters in the area

Parameters		**Increased**		**No change**		**Decreased**		**No answer**	
		Freq	**Percent**	**Freq**	**Percent**	**Freq**	**Percent**	**Freq**	**Percent**
Precipitation	Annual rainfall	0	0.0	0	0.0	42	97.7	1	2.3
	1st rains (march – may)	0	0.0	0	0.0	43	100.0	0	0.0
	2nd rains (Sept – Nov)	0	0.0	0	0.0	43	100.0	0	0.0
	Length of rain season (1st)	0	0.0	0	0.0	43	100.0	0	0.0
	Length of rain season (2nd)	1	2.3	0	0.0	42	97.7	0	0.0
	Intensity of rains	2	4.7	0	0.0	39	90.7	2	4.7
	Floods	2	4.7	16	37.2	21	48.8	4	9.3
Temperature	Dry season temperatures	43	100.0	0	0.0	0	0.0	0	0.0
	Rainy season temperatures	20	46.5	9	20.9	2	4.7	12	27.9
	Length of 1st dry season (June – August)	39	90.7	3	7.0	0	0.0	1	2.3
	Length of 2nd dry season (December – February)	39	90.7	0	0.0	1	2.3	3	7.0
	Frequency of droughts	39	90.7	0	0.0	0	0.0	4	9.3
Wind	Intensity in dry season	26	60.5	15	34.9	1	2.3	1	2.3
	Intensity in rainy season	19	44.2	17	39.5	5	11.6	2	4.7
Others	Lightening	13	30.2	26	60.5	0	0.0	4	9.3
	Thunder	14	32.6	25	58.1	1	2.3	3	7.0
	Hailstones	4	9.3	28	65.1	1	2.3	10	23.3

There has been a decrease in the amount of rains received annually, with the most decrease happening in the 1st rainy season between March to May with a percentage of 100% decrease as reported by farmers interviewed in the sub-county. This decrease has been reported to have started happening in the previous two years for example, from late 2020 to early 2022. The dry season temperatures have been observed to increase reported about by all farmers (100%) as the intensity of wind in the dry season increases where 60.5% farmers reported that thus is due to increased drought season that was observed by most households interviewed in the sub-county. The percentage of farmers who have reported the increase in drought frequencies were (90.7%) which was the biggest hindrance to their agricultural production in the area.

4.8 Farmers' Intervention mechanisms to Climate Change challenges

Adaptation measures applied by farmers in their communities in response to deteriorating climatic conditions were categorised into three. That is those applicable to crops, livestock, and soil and water resources.

4.8.1 Adaptations for crops growing

The biggest number of farmers mentioned early planting (92.3%) as the major adaption measure to climate change, in order to utilise the first rains of the season explaining that when they wait for rains to just be enough that's when instead it stops raining marking the end of rainy season leaving farmers without grown foods crops for their home consumption and for sale. Other commonly used adaptation measures that were cited include, intercropping different crops (56.4%), planting trees (33.3%), diversifying in agriculture (20.5%) shifting from livestock to crop (17.9%), and three farmers reported to be using irrigation, planting drought tolerant crop varieties and changing crop varieties which contributed to 7.7% of the total interviewed farmers.

4.8.2 Adaptations for livestock

The highest number of the farmers involved in livestock farming that were interviewed stated that they were rearing different livestock types (83.9%) to cope up with the unpredictable weather conditions reasoning that they can complement in others in terms of income. Stocking rate control (80.6%) and fencing off the grazing fields (61.3%) were other major measures used as these could be of importance to reduce the rate of rangeland degradation. Other adaptation measures identified included; migration (19.4%) which was in a controlled manner, practiced by a few farmers in the area and only two farmers mentioned about planting drought tolerant pastures (6.5%).

4.8.3 Adaptations for Soil and Water

Water harvesting (60.0%) and applying manure (56.0%) were the common practices to conserve water and soil resources respectively, some use private tanks and others communal valley dams to harvest and conserve water for dry season. The fertility in soil is mainly preserved by continued adding of both goats and cow dung in their crop fields, and some farmers reported that this also improves on the soil-water retention capacity (44.0%) which enables the annual crops to continue surviving and growing until the next rainy season. However, there were six farmers out of which three reported to be using organic fertilizers (12.0%) and the other three mentioned about abandoning their fields (12.0%) so that it could regain its fertility to support crops to be grown in the following season.

Table 14: adaptation to Climate Change measures used by farmers

	Adaptation Measures	Frequencies	Percent
Adaptation for crops	Planting trees	13	33.3
	Changing crop varieties	3	7.7
	Planting drought tolerant crops	3	7.7
	Intercropping different crop	22	56.4
	Diversifying agricultural production	8	20.5
	Shift from livestock to crop	7	17.9
	Early planting	36	92.3
	Irrigation	3	7.7
Adaptations in live-stock	Fencing off grazing fields	19	61.3
	Plant drought tolerant pastures	2	6.5
	Forage conservation	0	0.0
	Stocking rate control	25	80.6
	Keeping different livestock types	26	83.9
	Migration	6	19.4
	Shift from crop to livestock	0	0.0
Adaptation for soil and water	Soil and water conservation	11	44.0
	Use of fertilizers	3	12.0
	Use of manures	14	56.0
	Abandon fields	3	12.0
	Water harvesting	15	60.0

4.9 Farmers' knowledge about the decision making Criteria

In order determine the decision making criteria, farmers were interviewed and tasked to give their basis on where how they come with the decisions to opt for some adaptation measures over others. The weights were assigned to those measures based on their level of importance in accordance with different parameters such as community benefits, life-saving, humans and animals, protects the land, multi-purpose, proved and tested. Tree planting carried greater weight being helpful to farmers in terms of income to the households, controlling soil erosion and sustainable production.

4.10 Knowledge about the effectiveness of the Adaptation measures

In order to determine the effectiveness of different intervention measures applied by farmers, the average scores were assigned to each adaptation intervention by the help of farmers' knowledge and experiences in those practices. The effectiveness was measured against different parameters like conserving natural resources, enhancing capacities and livelihood opportunities, increasing food security and supply, effectiveness, technically feasible, socially acceptable, financially recoverable and feasible in existing institutional framework. The mean ranks were assigned as excellent =5, high =4, medium =3, low =2, very low =1 and no contribution or negative effect =0; The adaptations were then categorised as those applicable to crops, soil and water, and livestock and the farmers' responses on grading are as presented in the figures (3, 4, and 5) below.

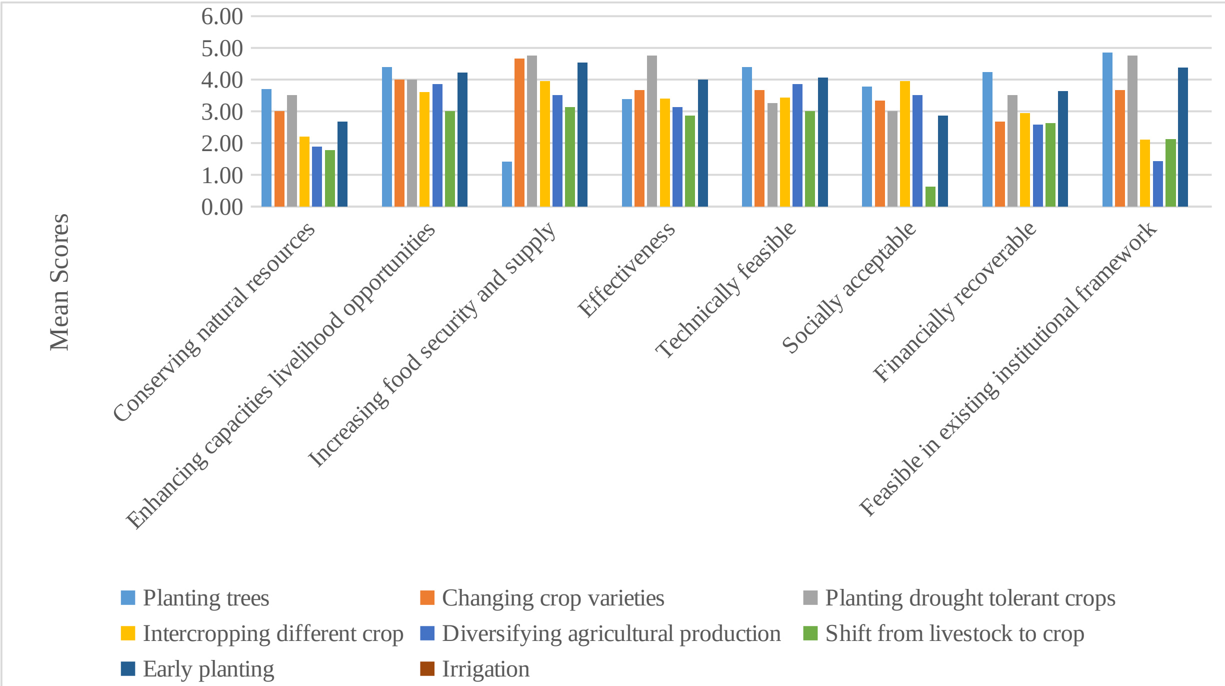

Figure 3: Mean Ranks for Crops adaptation measures

The most effective adaptation measures for crops used by farmers to overcome harsh climatic conditions were planting drought resistant crops with the mean rank of 4.75 followed by early planting with the mean rank of 4.00 and the least effective being shifting from crops to livestock with the mean value of 2.86 as displayed in the figure above.

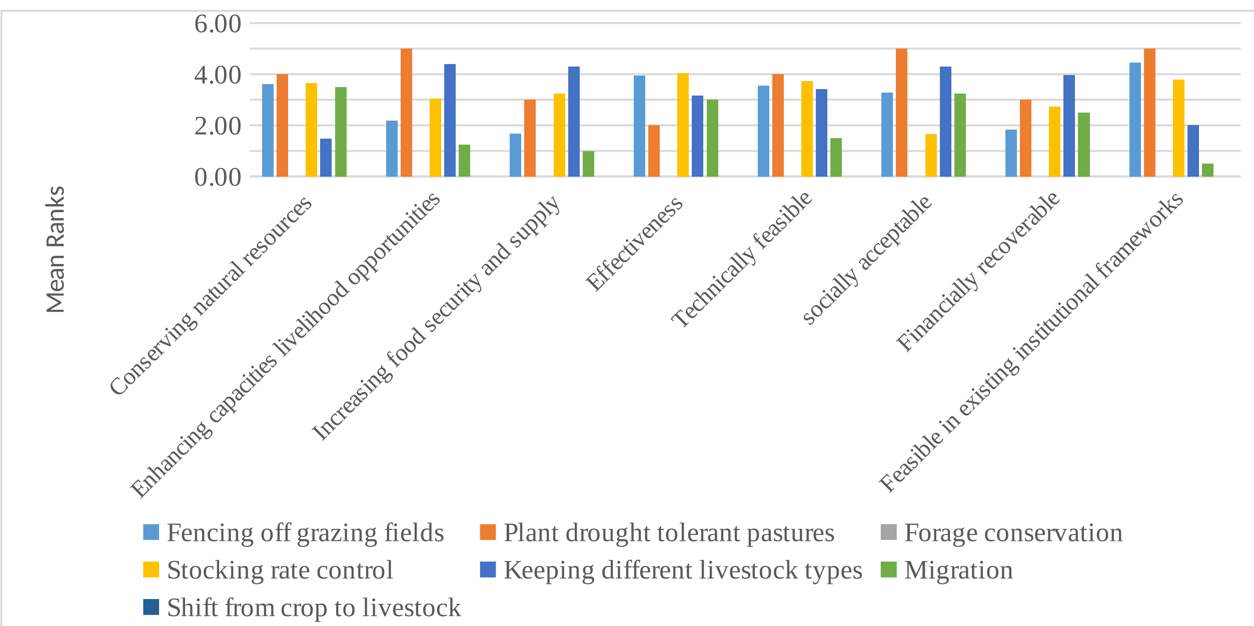

Figure 4: Mean Ranks for livestock adaptation measures

The most effective adaptation measure in livestock farmers to carb harsh climatic conditions was stocking rate control with the mean value of 4.05 followed by fencing off grazing fields with the mean rank of 3.94 and the least effective measure was planting drought tolerant pastures with mean rank of 2.00 as shown in the figure above.

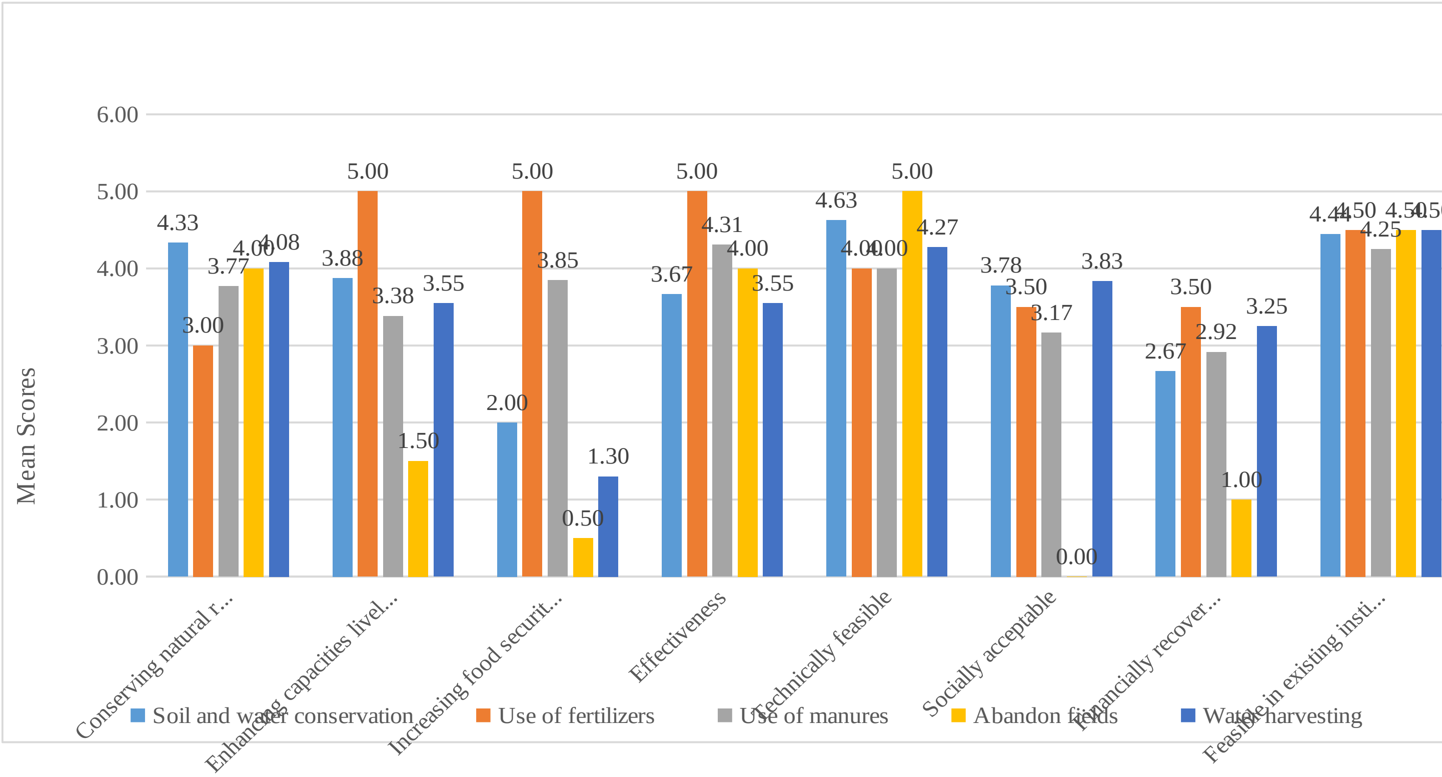

Figure 5: Mean Ranks for Soil and water adaptation measures

The most effective adaptation measures for soil and water conservation were through the use of fertilizers with the mean rank of 5.00 followed by the use of manures with the mean value of 4.31 and the least effective measure was water harvesting with the mean value of 3.55 as displayed on the graph above.

4.11 Factors Limiting farmers' involvement in climate change adaptation measures

In order to determine the major reasons as to why farmers have not engaged in a number adaptation measures, most of the respondents (65.1%) reported that poverty is the major hindrance to climatic adaptation measures, claiming to be lacking enough capital to put into these modern farming practices. (39.5%) of the farmers identified lack of water for irrigation to be a major hindrance to adopt irrigation in the area due to lack of both the means to access water and inadequate amounts. Destruction of crops or/ and pastures (32.6%) especially in the dry season where termites become so rampant due to lack of organic materials to feed on. Shortage of land (23.3%) of the farmers were found to lack full ownership of land and others had a very small piece where no much production could be done thus opted for the traditional ways of farming which resulted into hunger and poverty hitting the area most especially in the dry season. Drought, lack of access to improved crop varieties and lack of extension services are among other factors (7.0%) of the farmers identified to have failed them to adapt climatic change measures (Figure 6).

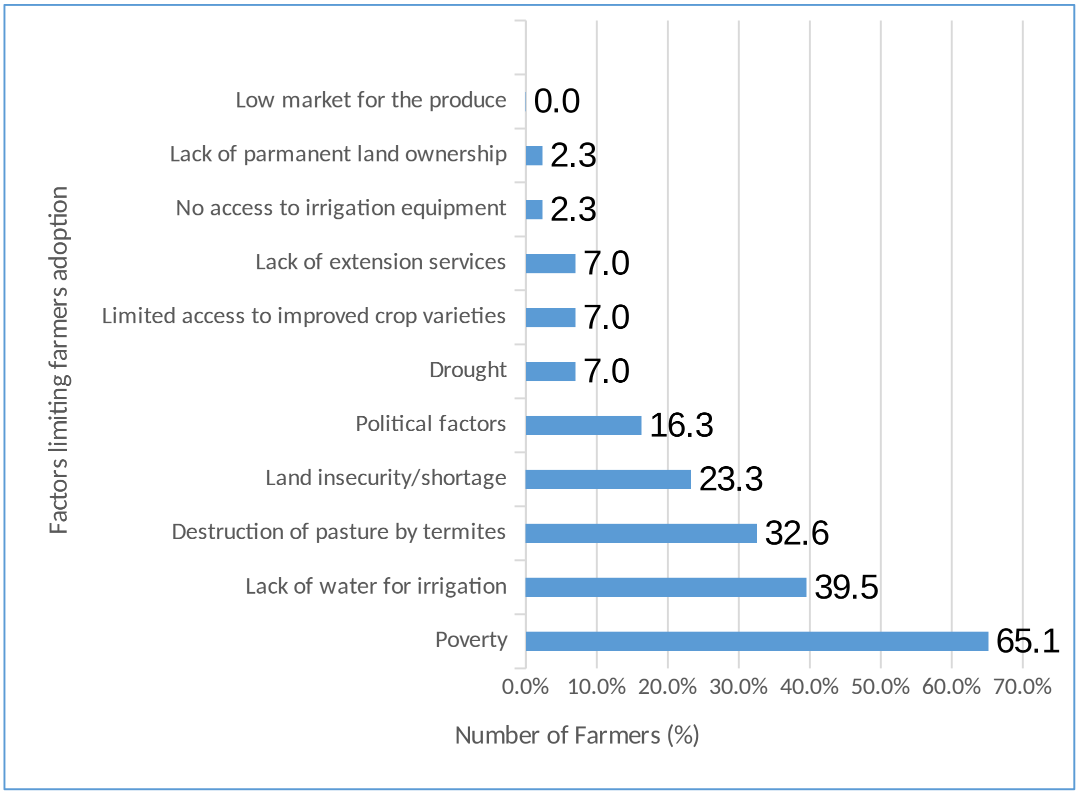

Figure 6: Factors Limiting Farmers from adopting Climate Change Mitigation and Adaptation Measures

With less involvement in modern ways of climate change adaptation measures, farmers were interviewed on what should be done to increase the adoption rate, where the majority (86.0%) of the farmers believed that more intensive sensitisation broaden climate change adoption measures. Some farmers (41.9%) suggested that government funds or Aid should be given to them to buy some irrigation equipment and improved crop or pasture varieties. There were those who suggest provision of improved seed varieties, and construction of reliable water sources to provide enough water in the dry season for irrigation, animal consumption and household use. Others recommended the on the improvement of the security of land ownership (20.9%) and proven ways of termites control (16.3%). While other farmers (7.0%) talked about providing subsidised irrigation equipment and availing cheap loans as this could be of a big help to enable those who can't afford those production costs. A few other farmers (2.3%) suggested of providing extension services and setting up demonstration farms to train farmers on the applicability of the climate change adaptation measures.

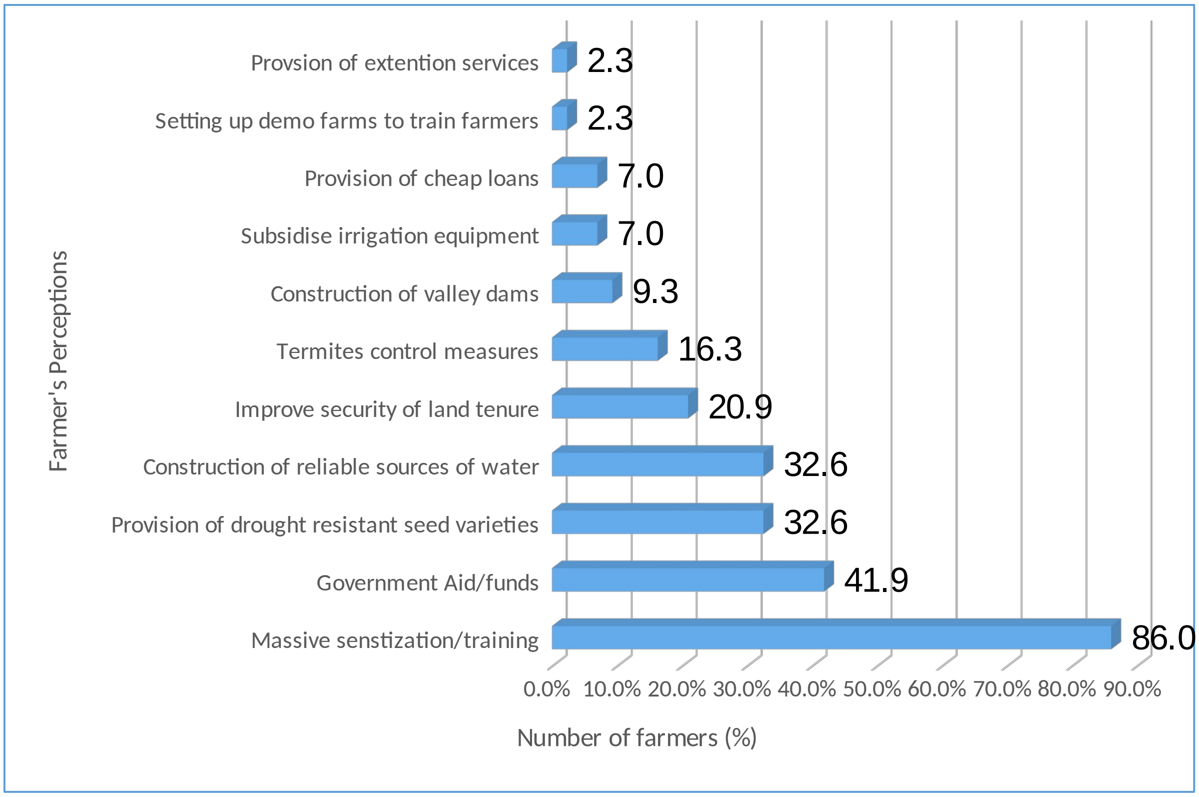

Figure 7: Recommendations suggested by farmers on what should be done to improve on the adoption of climate change measures

CHAPTER FIVE

DISCUSSION

The study was carried out to determine farmer's perceptions, attitude and knowledge to climate change impacts and their intervention or adaptation approaches in rangelands of Uganda.

Results indicated that all farmers were aware of the changes in the climate, and had experienced the impacts associated with this change. Some of the major impacts climate change has had on farmers were failure of the annual and perennial crops, low and/or no crop yields at all, outbreak of pests and diseases, termites surge and destruction of both pastures and crops. All these impacts were brought about due to high temperatures, drought that is prolonged passed the usual dry season. This is in line with other findings carried out in Uganda, for example, the increase in temperatures has already been reported to reduce crop yields in cereals and coffee reducing the area for coffee cultivation (Government of Uganda, 2007; Government of Uganda, 2012). As well as rainfall across the country has been noted to be unreliable and highly variable in terms of its onset, cessation, amount and distribution, leading to either low crop yields or total crop failure (Mubiru et al., 2012).

The analysis showed that few farmers had limited knowledge on the modern climate change adaptation intervention approaches. Most of the intervention practices were local and less effective yet applied by most farmers in the community because some farmers were ignorant of the modern adaptation measures claiming that they have never heard about them, other farmers perceived that those measures were costly they lacked enough capital to invest in them, while others were not interested at all in those modern practices because of the frustration due to the failure of some measures they had applied earlier. Coping strategies to protect farmers against climate related impacts included intercropping, planting early and tree planting. Other strategies included planting early-maturing varieties, high-yielding varieties, drought-tolerant varieties, disease and/or pest-resistant varieties, income diversification, increased pesticide/fungicide application, among others. Similar coping strategies were reported from various studies conducted in different parts of Africa like Ethiopia, South Africa and Nigeria (Hassan & Nhemachena, 2008; Deressa et al., 2009; Salau et al., 2012).

Adaptive capacity of smallholder farmers to changes in climatic events is usually low due to dependence on natural resources, constraints in human and physical capital, and poor infrastructure (Shewmake, 2008; Salau, 2012; Gukurume, 2013). In this survey, factors that hindered adaptation included poverty (inability to pay for farm inputs, equipment and services like labor), unreliable weather forecasts, and shortage of food to store, among others.

The survey showed that there was a great decrease in natural forests and woodlands in the community due to deforestation for mainly cultivation where new areas have been opened up in search for more fertile soils and expansion of the existing fields. This has been found out by other researchers in that because of the limited potential of soils in this area to support crop growth and the practice of low input agriculture, farmers often opened up new areas in search of fertility, in the process encroaching on woodland, bushland, grassland and wetland (Byenkya at el., 2014).

Basing on this study, most of the farmers had come up with some kind of coping mechanisms to the changing climatic conditions to enable them have sustainable production throughout the season. Small scale farmers were applying simple adaptive measures like early planting thus depending on the rain fade agriculture which made it so hard for them to have continued production throughout the season because of poor timing of the first rains and how long they would last. This calls for provision of adequate information to ensure that farmers receive up to date weather forecasts. This is important for decision making to either use early and late planting as an adaptation strategy by farmers. Very few of the farmers were involved in irrigation systems for their fields. This was due to financial constraints that many were unable to afford buying irrigation equipment and installation services. This is in line with a study carried out in the Central Rift Valley of Ethiopia where they noted that only a few respondents practiced irrigation, even though there were lakes in some parts of their study area, they were inaccessible for irrigation because there was need for high capital investments in designing the irrigation infrastructure (Belay et al., 2017). Other major adaptation strategies included early planting which was practiced widely though farmers could not predict how long the rains would last thus a need for the government to put more efforts into providing farmers with accurate weather forecasts as most farmers have no confidence in the weather forecasts received. Adaptive capacity of smallholder farmers to changes in climatic events is usually low due to dependence on natural resources, constraints in human and physical capital, and poor infrastructure (Shewmake, 2008; Salau, 2012; Gukurume, 2013).

The results showed that although diverse climate change adaptation strategies exist in the area, the farmers were not practicing them to their full potential due to constraints. The major constraint was the lack of enough capital for investment. About 65.1% of the respondents reported to be poor and unable to cover up such costs as the major constraint to adaptation to climate change (Figure 3). Lack of sufficient money hindered farmers from getting the necessary agricultural inputs. This was followed by shortage of water for irrigation, destruction of crops by termites, shortage of land and lack of full land ownership, political factors, drought, lack of extension services and without access to irrigation equipment respectively. Also the farmers did not have sufficient family labor and were not able to employ laborers. Shortage of farmland has been associated with the limited capacity of farmers to intensify their agricultural production.

The other challenge that was cited by crop farmers was the destruction of their crops by their neighbors' animals involved in animal rearing due to poor fencing in that animals move freely especially at night and destroy crop gardens. This is agreement with the earlier research done in some cattle corridors in Buriisa, where it was noticed that in cultivated areas, conflicts were common between crop and livestock farmers during migration (Byenkya et al., 2014). As this continues to happen every season, the crop farmers are discouraged to adopt the improved climate change practices knowing that this will yield them nothing after all.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The conclusions are;

- The majority of the farmers have perceived changes in rainfall and experienced the effects of changing climate over a period of three decades. The impacts harsh climate has had on their agricultural practices were mostly irreversible and has led to hunger and poverty strike in the community especially in the dry season. That is, extended dry periods and declining precipitation are more frequent across the region in the sub-county. As a result, both livestock and crop production by small holder farmers have already been adversely affected. The farmers are trying to adapt through the use of improved agricultural practices like increasing on-farm tree planting, soil and water conservation, adjustment of planting dates, crop diversification, improved crop varieties, and use of agricultural inputs like fertilizers and pesticides.

- Farmers had limited knowledge on the modern coping and/or adaptive mechanisms to harsh climate changes. Therefore, with their less expertise, unproven, un-mechanized adaptive control measures, less or no results were achieved.

- Due to less knowledge and limited places where farmers could acquire knowledge on modern farming practices and less capital for investing in modern equipment, the spread of modern climate change adaptation measures has been very low in the area.

6.2.1 RECOMMENDATIONS

The Recommendations are;

- Government institutions need to put more efforts into providing farmers with accurate weather forecasts as most farmers have no confidence in the weather forecasts received. This will enable farmers to fully exploit seasonal rainfall distribution to improve and stabilize crop yields.

- There is need for the government of Uganda to facilitate the development and dissemination of agricultural technologies such as integrated pest management (IPM) to substitute the use of pesticides as well as drought-tolerant and early-maturing varieties by research institutions through increased funding to the agricultural sector.

- Due to less knowledge coverage for the improved and proven climate adaptation measures in the community, famers need to be trained and sensitized on the better approaches to climate adaption measures through their trusted model farmers in cooperation with the government extension workers who are able to train the farmers step by step adaptation procedures until a certain set goal is achieved.

- In some villages water had become the biggest hindrance to apply irrigation practices. In some instances, it's scarcity would become so intense to the extent that some families would fail to access clean water for home use. The government should provide more valley dams to the community people and also train the farmers on the ways of water harvesting during rainy seasons when water is plenty so that there is enough for use in the times of scarcity.

- As the rainy seasons are recently becoming more and more unpredictable and uncertain, depending on rain-fed agriculture in the area is less unlikely and hence policy driven actions to provide irrigation facilities based on both ground and surface water are vital.

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APPENDICES

Appendix 1 House hold survey questionnaire

This questionnaire is prepared to collect data for research proposal entitled "assessing the effectiveness of climatic change adaptation interventions by agro-pastoralists A case study of Nabiswera Sub county, Nakasongola district." The questionnaire is designed to generate data that will be used for academic purposes only. Therefore, please feel free and share with me your rational view for the sustainable development of the society

The information collected is for research purposes and strictly confidential

Enumerator's name ....

Date of Interview ....

General household information	
Name of household head	
Gender of household head	
Name of respondent	
Gender of respondent	
Marital status of respondent	
Education level of respondent	
Name of second respondent (if applicable)	
Gender of second respondent (if applicable)	
Geographical location	
District	
Sub-county	
Parish	
Production system (E.g. Agro-pastoral, Crop farming, Pastoral)	

Appendix 2

A: Household composition and farm activities

(i) How many years has you/household stayed in this village……………………………….

B. Land ownership and utilization

(i) Number and size of parcels owned by household

Parcel	Acreage	System of ownership
1		
2		
3		
4		
Mailo land, customary, leasehold, communal land		

(ii) Land allocation to different enterprises

Enterprise	Acreage Currently	Current Acreage in early 2000
Grazing (ruminant production)		
Non-ruminant production		
Annual crops		
Perennial crops (e.g. coffee, banana, etc.)		
Apiculture		
Agro-forestry (e.g. Oranges, Mangoes)		
Furrowed land		
Bushes and shrubs		
Forests/woodlands (Natural)		
Degraded/abandoned		
Planted Trees/ Forests (E.G. Pine/Eucalyptus)		

(iii) Major livestock types and numbers owned

Type	Number owned in Early 2000	Current number owned	Current Rank economic importance	Current Rank food security
Cattle				
Sheep				
Goat				
Pigs				
Others				

Appendix 3

(iv) For ruminants, what grazing management system do you practice?

1. Extensive grazing on natural pastures (private fenced)
2. Extensive grazing on improved pastures (private fenced)
3. Communal grazing
4. Tethering

(v) What are reasons for changes in livestock types and numbers kept between 2000 and 2022?

Reason	Tick all	Rank (1 is strongest)
Changes in land ownership from communal to individual		
Shortage of land		
Changes in production goals from more animals to high producing animals		
Changes in animal breeds from indigenous to exotics and crosses		
Increased pasture scarcity		
Increased water scarcity		
Lack of Government subsidies to livestock producers		
Frequent droughts		
Unpredictability of seasons		
Increased incidences of pests and diseases		
Government policies		

(vi) Major crops grown and their importance to household

Crop (list all crops currently grown)	Acreage in Early 2000	Current acreage	Current Rank economic	Current Rank food security

(vii) What are the reasons for changes in crops grown and acreage in the previous years?

Reason	Tick all That apply	Rank (1 is strongest)
Changes in markets		
Shortage of land		
Need to diversity in come		
Declining soil fertility		
Need to produce own food		
Changes in seasons		
Unpredictability of seasons		
Increased incidences of pests and diseases		
Frequent droughts		
Government policies		

Appendix 4

C. CHALLENGES TO AGRICULTURAL PRODUCTION

(i) What are the major challenges to agricultural production in this area?

List challenges	Rank challenges
1	
2	
3	
4	
5	

(ii) Are you aware of any changes in climate? Yes…………… No……………….

(iii) If yes, what is your perception on the following climate change parameters in this area?

Parameter	Description	Increased	No change	Decreased	No answer
Precipitation	Annual rainfall				
	1st rains (March – May)				
	2nd rains (Sept – Nov)				
	Length of rain season (1st)				
	Length of rain season (2nd)				
	Intensity of rains				
	Floods				
Temperature	Dry season temperatures				
	Rainy season temperatures				

6

	Length of 1st dry season (June – August)				
	Length of 2nd dry season (December – February)				
	Frequency of droughts				
Wind	Intensity in dry season				
	Intensity in rainy season				
Others	Lightening				
	Thunder				
	Hailstones				
Any other observation					
Give years when you experience severe droughts in the last 30 years					
Give years when you experienced excess rainfall (floods) in the last 30 years					

Appendix 5

(iv) Do the observed changes in climatic parameters affect agricultural production and livelihood
Yes…………… No………………

(v) If yes, what is your perception on the impacts of climate change on the following?

Category	Impact	Climatic cause (E.G excess rain, low temp.)
Annual crops		
Perennial crops		
Livestock		
Soils		
Water resources		
Vegetation		
Invasive species		
Pasture production & biodiversity		
Human health		

(vi) What do you think are the major causes/drivers of the observed changes in climate parameters?

Causes	Remarks
1. God's wish	
2. Pollution from outside the community	
3. Farming practices within community (E.G deforestation, swamp clearing)	
4. Changes are just normal and expected	
5. Ancestors not happy with us	

Appendix 6

(vii) Which category of people is most affected by the impacts of climate change to agricultural production?

Category	Rank of effect	How are they affected	Coping mechanism developed
Men			
Women			
Youth			
Children			

(vii) What mitigation/adaptation measures do you practice and what benefits do you derive from them?

Measure	Tick Practiced	What benefits do you get from adaptation measures						
		Increased soil fertility	Reduced soil erosion	Increased crop/animal yields	Increased pasture biomass	Sustainable production	Increased water availability	Increased income
Adaptations for crop								
Planting trees								
Changing crop varieties								
Planting drought tolerant crops								
Intercropping different crop								
Diversifying agricultural production								
Shift from livestock to crop								
Early planting								
Irrigation								
Adaptations for soil and water								
Soil and water conservation								
Use of fertilizers								
Use of manures								
Abandon fields								
Water harvesting								
Adaptations in livestock								
Fencing off grazing fields								
Plant drought tolerant pastures								
Forage conservation								
Stocking rate control								
Keeping different livestock types								
Migration								
Shift from crop to livestock								

Others….

Appendix 7

(viii) Rank the mitigation/adaptation measures basing on these parameters as (Excellent = 5; High = 4; Medium = 3; Low = 2; Very low =1 no contribution or negative effect = 0)

	Conserving natural resources	enhancing capacities and livelihood opportunities	Increasing food security and supply	Effectiveness	Technically feasible	Socially acceptable	Financially recoverable	Feasible in existing institutional framework
Adaptations for crop								
Planting trees								
Changing crop varieties								
Planting drought tolerant crops								
Intercropping different crop								
Diversifying agricultural production								
Shift from livestock to crop								
Early planting								
Irrigation								
Adaptations for soil and water								
Soil and water conservation								
Use of fertilizers								
Use of manures								
Abandon fields								
Water harvesting								
Adaptations in livestock								
Fencing off grazing fields								
Plant drought tolerant pastures								
Forage conservation								
Stocking rate control								
Keeping different livestock types								
Migration								
Shift from crop to livestock								
Others								

(ix) What are the factors limiting the adoption of climate change mitigation and adaptation measures

1.
2.
3.
4.
5.

(x)What should be done to increase the adoption of climate change mitigation and adaptation measures?

1.
2.
3.
4.
5.