

**EFFECT OF CLIMATE CHANGE ON SMALL-HOLDER FARMERS'
LIVELIHOODS IN MANAFWADISTRICT, UGANDA**

OLUPOT JUSTIN

BU/GS18/MCC/34

**A RESEARCH THESIS SUBMITTED TO THE SCHOOL OF
POSTGRADUATE RESEARCH AND INNOVATIONS IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD
OF THE DEGREE OF MASTER OF CLIMATE CHANGE
AND DISASTERMANAGEMENT OF
BUSITEMAUNIVERSITY**

October, 2025

DECLARATION

I, **Olupot Justin**, declare that this dissertation is my original work, except where due acknowledgement has been made. I declare that this work has never been submitted to this university or any other institution for funding or fulfillment for any award.



.....
Olupot Justin

BU/GS18/MCC/34

Date:

4/11/2025

APPROVAL

This research dissertation is submitted as a partial fulfillment for the award of Masters of Science in Climate Change and Disaster Management of Busitema University, with my approval as the academic supervisor.

Dr. Masaba Sowed

Signature: 

Date: *04/11/2025*

DEDICATION

I dedicate this work to my family and all friends whose tireless efforts gave a firm background to my academic path up to this level and particularly my family members (Wife: Gloria Olupot, Children: Eliora Olupot, Elijah Olupot and Ellion Olupot) who withstood the thick and thin because of my decision to pursue further studies.

ACKNOWLEDGEMENT

In writing this dissertation, I drew a lot of inspiration from my fellow students, who often put me right whenever I was stuck; to them I express my heartfelt appreciation. I owe many thanks to several persons who were particularly helpful to me; among them are my supervisor whose supervision and guidance afforded me a smile. I also express my gratitude to the authorities of Busitema University, particularly Faculty of Natural Resources and Environmental Sciences, for availing me the necessary facilities and to the lecturers in the department whose knowledge and skills enabled me to achieve my goal as a Masters student.

TABLE OF CONTENTS

DECLARATION	Error! Bookmark not defined.
APPROVAL	Error! Bookmark not defined.
DEDICATION	4
ACKNOWLEDGEMENT	5
TABLE OF CONTENTS.....	6
LIST OF FIGURES	10
LIST OF TABLES	11
LIST OF ACRONYMS	13
ABSTRACT.....	14
CHAPTER ONE: INTRODUCTION.....	16
1.1 Background	16
1.2 Problem statement.....	17
1.3 Purpose of the study	17
1.4 Specific Objectives.....	17
1.5 Research questions	17
1.6 Scope of the study	18
1.7 Significance/ Justification of the study	18
1.8 The conceptual Framework.....	18

<i>Figure 1.1: Conceptual Framework the sustainable livelihood framework (adapted from DFID, 2000)</i>	19
CHAPTER TWO: LITERATURE REVIEW	19
2.1 Smallholder farmers’ perception and understanding of climate change	20
2.2 Small-holder farmers’ livelihoods amidst climate change	22
2.3 Climate change adaptation strategies by smallholder farmers	24
2.4 Theoretical Perspectives on Climate Change and Livelihoods	27
2.5 Identified Gaps in the Literature	27
2.6 Summary and Critical Reflection.....	28
3.0 Introduction	29
3.1 Research design.....	29
3.2 Study Area Description	29
3.2.1 Location.....	29
3.2.2 Rainfall.....	29
3.2.3 Soils.....	30
3.2.4 Vegetation	30
3.2.5 Drainage	30
3.2.6 Relief	31
3.2.7 Demography.....	31

<i>Figure 3:1. Administrative units of Manafwa (source, Manafwa District statistical Abstract 2019-2020)</i>	32
3.3 Study population	32
3.4 Sample size.....	32
3.5 Sampling Procedure	33
3.6 Data Types and Sources	33
3.7 Data Collection Methods and Tools.....	34
3.8 Data Analysis	34
3.9 Operational Definition of Variables.....	34
3.11 Ethical considerations	37
3.10 Limitations and delimitations of the study	37
CHAPTER FOUR: DISCUSSION OF RESULTS	38
4.1 Socio-economic demographic characteristics of the respondents.....	38
4.2. Smallholder farmers’ perception and understanding of local climate change	39
4.3 Effects of Climate Change on smallholder farmers’ livelihoods	51
4.4 Adaptation strategies employed by respondents	57
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS	65
5.0 Introduction	65
5.1 Conclusion.....	65

5.2 Recommendations	67
References.....	69
APPENDICES	78
APPENDIX I: INTERVIEW SCHEDULE FOR KEY INFORMANTS	78
APPENDIX 2: GUIDING QUESTIONS FOR FOCUS GROUP DISCUSSIONSWITH SELECTED FARMERS.....	81

LIST OF FIGURES

Figure 1.1: Conceptual Framework the sustainable livelihood framework (adapted from DFID, 2000).....	17
Figure 3:1. Administrative units of Manafwa (source, Manafwa District statistical Abstract 2019-2020).....	27
Figure 4:1. A Farmer practicing second ploughing using oxen before planting.....	32
Figure 4:2. Pie chart showing the percentage of respondents who had witnessed climate change.....	32
Figure 4:3. Perception of respondents on the major climatic changes noticed.....	35
Figure 4:4. Perception of respondents on changes in temperature.....	37
Figure 4:5. Perception of the respondents on drought notices in the study area.....	39
Figure 4:6. Perception of respondents on the effects of climate change on livelihood.....	44
Figure 4:7. Effects of climate change on water for crop production.....	44
Figure 4:8. Perception of respondents on diseases induced by changes in climate.....	45
Figure 4:9. Perception of respondents on the impacts of climate change on crop yields.....	47
Figure 4:10. Percentage of respondents practicing adaptation strategies.....	50
Figure 4:11. Contour ploughing and terracing as adaptation strategy used by some of the farmers in the study area.....	51
Figure 4:12. A section of farmers land planted with trees as an adaptation strategy.....	52
Figure 4:13. A farmer using family labour to drain water logged garden before planting in Lwanjusi Sub-county.....	54
Figure 4:14. Percentage of respondents who own sources of water for irrigation.....	56
Figure 4:15. River Nangilima which has always acted as a source for irrigation water.....	56

Figure 1.16.Irrigation of cabbage in Kato sub-county, which has enabled farmers to produce throughout the year57

LIST OF TABLES

Table 4.1: Perception of respondents on the causes of climate change.....34

Table 4:2. Relationship between demographic factors and the possibility to notice a change in climate.....	36
Table 4:3. Perceptions of the respondents on the major weather changes noticed.....	37
Table 4:4. Relationship between times spent in the area and the possibility to notice climate changes.....	38
Table 4:5. Perception of the respondents about changes in rainfall received.....	39
Table 4:6. Perception of respondents about the change in flooding events.....	39
Table 4:7. Relationship between drought notices and demographic factors.....	41
Table 4:8. Months of excess temperatures.....	41
Table 4:9. Months of the year in which excess rainfall is noticed in the study area.....	42
Table 4:10. Months of the year in which excess rainstorms are noticed in the study area.....	42
Table 4:11. Months of the year in which excess windstorms are noticed.....	43
Table 4:12. Months of the year in which severe sandstorms are noticed in the study area.....	43
Table 4:13. Months of the year in which excess droughts are noticed in the study area.....	44
Table 4:14. Months of the year in which excess droughts are noticed in the study area.....	44
Table 4:15. Relationship between climate changes noticed and water for production.....	46
Table 4:16. Relationship between flooding events and increase in crop diseases.....	47
Table 4:17. Climatic changes noticed in the study area and their significance to the crop growing season.....	48
Table 4:18. Effect of climate change on farm markets.....	49

Table 4:19. Effect of climate change on crop quality.....	49
Table 4:20. Effect of climate change on soil fertility.....	50
Table 4:21. Effect of climate change on crops.....	51
Table 4:22. Adaptation strategies practiced by respondents in the study area.....	52
Table 4:23. Relationship between adaptation to climate change and demographic factors.....	53
Table 4:24. Alternative adaption strategies adopted by respondents.....	54
Table 4.25. Challenges faced by farmers during the implementation of adaptation strategies..	54
Table 4:26. Percentage of respondents who had access to extension services.....	56
Table 4:27. Factors influencing access to agricultural extension services.....	56

LIST OF ACRONYMS

- FGD** : Focus Group Discussions
- KIIs** : Key Informant Interviews
- CC** : Climate Change

S.H.F : Small Holder Farmers

NEMA : National Environmental Management Authority

UNMA : Uganda National Meteorological Authority

FAO : Food and Agricultural Organization

UBOS : Uganda National Bureau of Standards

UNHS : Uganda National Household Survey

ABSTRACT

The aim of the study was to assess the effects of climate change on smallholder farmers in Manafwa District of Uganda. Specifically, the study assessed the community awareness and knowledge about climate change; the indicators, causes, effects, adaptation and mitigation measures employed and the challenges encountered by small holder farmers in response to climate

change impacts. A survey of 398 households, two FGDs and six key informant interviews were conducted. Survey data was analyzed with help of Stata version 16 whereas qualitative data was analyzed by way of manual coding. Climate-related hazards such as floods, landslides, prolonged droughts, too much rains, hailstorm presence, wind storm presence and temperature extremes were identified as major indicators of changing climate conditions. The study revealed that climate change affects smallholder farmers in a number of ways, including; destruction of crops, reduced soil fertility, increased crop pest and disease incidences, among others. Farmers adopted various adaptation practices and measures, including mulching, terracing, and diversifying crop types to improve resilience to climate impacts. The major issues hindering climate change adaptation were; the high cost of the available climate change adaptation mechanisms coupled with the high poverty levels among the small holder farmers.

The study recommends increasing farmer education and awareness through, sensitization, community training programs, design and implementation of development programs that provide alternative livelihood sources for the small holder farmers were recommended to effectively manage and reduce climate change impacts.

Key words: Climate change, livelihoods, adaptation, small holder farmers

CHAPTER ONE: INTRODUCTION

1.1 Background

For centuries, smallholder farming has been an important and integral part of humanity. It was more of a subsistence practice, whose aim was to get food and also maintain ecological balance (Altieri et al., 2012). Due to the persisting climatic changes, smallholder farmers continue to be at risk (Harvey et al., 2014). Farmers and communities' dependence on smallholder farming is being threatened (Morton, 2007). Changes in climate affects farming, ecosystems, peoples livelihoods in the entire world with changes seen mainly in decrease and increase in the areas suitable for growing some of the major crops, such as beans, maize, and coffee. Projections suggest that, by the end of the 21st century, climate change will have had substantial impact on agricultural production and, hence, on the scope for reducing poverty (Slater et al., 2007). Generally, smallholder farmers in developing countries are the hardest hit by the effects of climate change (Mutekwa, 2009). According to Egeru et al. (2019), Uganda's mean temperature could rise between 1.5°C and 4.3°C by the end of the century. However, the impacts of the changing are not the same some areas due to the differences in nature of hazards in different parts of the world, but also due to differences in the ecological and socio-economic environment, which mediate these hazards and determine the severity of impacts. Manafwa District is one of the areas located along the slopes of mountain Elgon that is prone to the aspects of changing climate like flooding and landslides, causing some families to get displaced thereby ushering in the problem of food insecurity (Okau, 2023). The increasingly changing rainfall patterns in the area are generally viewed as an impact of climate variability. The above provided information suggests the occurrence of a continuous trend of unpredictable changes in weather events that are likely to affect smallholder farmers' livelihood. In order to address the above, it's paramount to have a thorough understanding and assessment of the impact of changing climate on smallholder farmers' livelihood.

1.2 Problem statement

Uganda is one of the countries experiencing the effects of climate change (Hisali et al., 2011). The Government of Uganda has come up with measures such as ecosystem based adaptation, including; restoration of degraded landscapes and wetlands, conserving watersheds (TO & EBA, 2010), soil and land management practices and promoting agricultural resilience practices. Despite above mentioned interventions, smallholder farmers in Manafwa District continue to experience the effects of the changing climate (Kitoyi, 2023).

There has been noted increase of water levels in rivers e.g. River Manafwa, Lwakhakhwa, and Tsutsu leading to flooding, siltation of rivers, soil erosion and increase in bushfires during dry season (OPM, 2015). The effect of climate change on smallholder farmers' livelihoods in Manafwa district has, however, not been studied.

1.3 Purpose of the study

The aim of the study was to examine the effect of climate change on smallholder farmers' livelihoods in Manafwa District.

1.4 Specific Objectives

1. To analyze smallholder farmers' perception and understanding of local climate change.
2. To assess the small-holder farmers' livelihood situation amidst climate change in Manafwa District.
3. To find out the adaptation strategies undertaken by small-holder farmers in Manafwa District.

1.5 Research questions

1. What is the farmers' perception and understanding of local climate change?
2. How has climate change affected the livelihoods of smallholder farmers in Manafwa District?
3. What are the adaptation strategies undertaken by smallholder farmers in Manafwa District?

1.6 Scope of the study

The study focused on understanding the effect of changing climate on the livelihoods of smallholder farmers in Manafwa District. The study also examined the farmers' perception and understanding of the prevailing changes in climate as well as the strategies used by the farmers to adapt to the changing climate. The study examined the above parameters in ranges of five years from the year 2000 to 2020.

1.7 Significance/ Justification of the study

Smallholder farmers are characterized by having fragmented plots of land undertaking various agricultural enterprises for both livelihood and food security. Due to their nature and format of operation, they are normally least targeted by policy formulators and implementers during climate change related crisis periods like drought, floods and pest & disease manifestation. There is lack of sufficient knowledge among farmers on issues concerning changes in climate. Therefore, ascertaining the farmers' perception and understanding of climate change will go a long way in developing climate change adaptation and mitigation strategies for smallholder farmers that will address the prevailing weather concerns like flood and erosion control measures, pests and disease management, planting of early maturing varieties and use of irrigation technologies.

1.8 The conceptual Framework

The study applies the sustainable livelihoods framework (figure 1.1) according (DFID, 2000) and the five capitals by to (Donovan and Stoian, 2012). The livelihood outcomes (dependent variables) such as increased household income, sustainable use of natural resource base, food security and reduced vulnerability depends on human, natural, financial, social and physical capital (independent variables). In order for the livelihood outcomes to be achieved, there is need for a sustainable use of the available capital resources. This can only be regulated by available local laws, policies, culture, institutions and processes (intervening variables). The Sustainable livelihood framework (SLF) is the core of the Sustainable Livelihoods Approach (SLA); the framework can be understood as a tool for comprehending poverty as the poor perceive it (DFID 2000). Climate change as an external shock that affects smallholder farmers' livelihood assets,

modifies their strategies, and influences outcomes. The DFID Sustainable Livelihood Framework is thus used as an analytical lens to: Identify which assets are most affected by climate variability, examine how farmers' perceptions shape adaptation and evaluate the effectiveness of adaptation strategies in building resilience and sustaining livelihoods. The DFID Sustainable Livelihood Framework (2000) provides a strong conceptual basis for understanding the linkages between climate change, farmers' assets, and adaptation behavior. It ensures that the study captures not only the environmental dimension of climate change but also its social, economic, and institutional implications for smallholder farmers in Manafwa District.

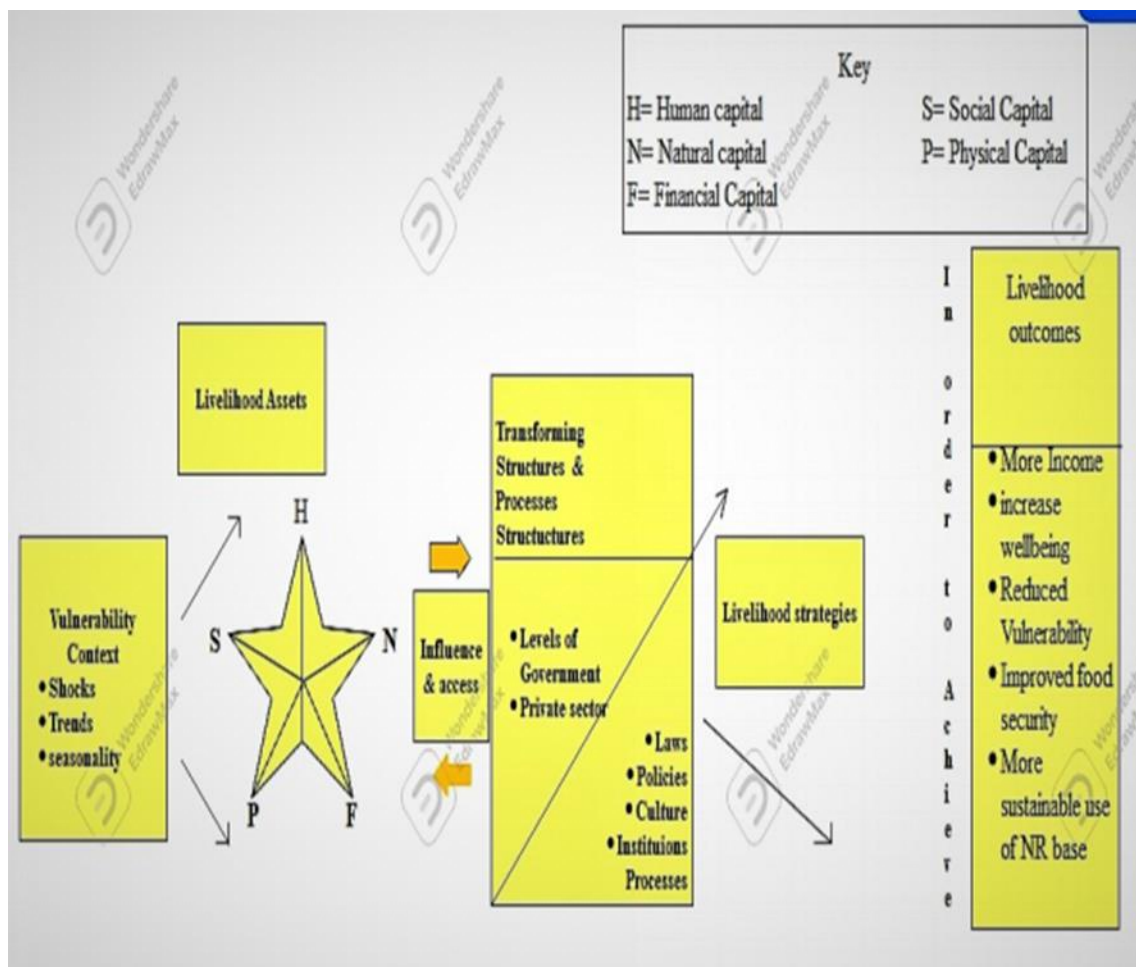


Figure 1.1: Conceptual Framework the sustainable livelihood framework (adapted from DFID, 2000)

CHAPTER TWO: LITERATURE REVIEW

This chapter provides a critical review of academic literature that examines how climate change influences the livelihoods of smallholder farmers. The discussion is organized according to the primary aims of the study: to evaluate farmers' perceptions and awareness of climate change, to analyze its effects on their sources of livelihood, and to investigate the adaptive responses undertaken by smallholder farmers. The review draws from international, regional, and national studies—placing particular emphasis on sub-Saharan Africa and Uganda—to build both a conceptual background and an empirical context for the research.

2.1 Smallholder farmers' perception and understanding of climate change

Empirical Studies on Climate Change and Agriculture show that globally climate change has led to reduced crop production and increased livelihood insecurity among smallholder farmers (Thornton et al., 2014). In Sub-Saharan Africa, studies by Deressa et al. (2011) and Osbahr et al. (2018) highlight that prolonged droughts and erratic rainfall patterns have disrupted planting calendars and reduced production of staple crops such as cassava and beans. However, these studies often generalize findings across many regions, overlooking the micro-level variations that take place between agro-ecological zones. Within Uganda, many studies reveal significant agricultural impacts. Nsubuga and Namutebi (2019) observed that more rainfall variability in Eastern Uganda has led to frequent landslides and soil erosion, particularly in highland districts such as Manafwa and Bududa. Similarly, Tumushabe (2018) realized that floods and droughts have increased food insecurity and poverty in rural areas. Yet, most of research efforts depend significantly on meteorological and yield information, providing limited insight into how households adapt or widen their income sources in response to climatic stressors. Critically, not many studies capture the subjective experiences and perceptions of smallholder farmers, which are important for understanding adaptive behavior. This gap points to the need for qualitative approaches that can capture farmers' voices and lived realities, complementing present quantitative analyses.

Climate change and climate variability continue to pose some of the greatest challenges to humanity across the globe (Thornton et al., 2014). The problem is particularly severe in developing countries, where a large share of the population depends on climate-sensitive livelihoods and has limited adaptive capacity (Nath & Behera, 2011). According to the Fifth Assessment Report of the

IPCC's Working Group II, the impacts of climate change are projected to intensify existing poverty levels in many low-income countries (Mcguigan et al., 2002). This is especially true in rural areas of Africa, where millions continue to experience hunger and food insecurity. Recent studies confirm that climate change has already had adverse effects on agriculture and food security across sub-Saharan Africa. The dependence on rain-fed farming systems makes African agriculture extremely vulnerable to the changing climate (Cooper et al., 2008). Climate change has been linked to a decline in agricultural productivity, heightened food insecurity, job losses, depletion of natural resources, and increased competition over scarce resources (Fonta et al., 2011). In Uganda, extreme weather patterns and climate variability have significantly reduced agricultural output and exacerbated food insecurity, poverty, displacement, and social conflicts (IPCC, 2014). Agriculture remains the backbone of Uganda's economy, accounting for 52% of the gross domestic product (GDP), about 80% of total employment, and over 80% of foreign exchange earnings. It is therefore central to both income generation and food security (Shepherd, 2016).

However, productivity within Uganda's agricultural sector remains low due to several interrelated factors. These include the use of traditional farming methods, severe land degradation caused by deforestation and overgrazing, limited access to institutional support services such as extension, credit, and markets, as well as climatic extremes like prolonged droughts and floods (Pender et al., 2004). These factors undermine the adaptive capacity of smallholder farmers, leaving them more vulnerable to the effects of climate change.

Farmers' awareness and understanding of climate change play a vital role in shaping their access to climate-related information and their subsequent adaptation choices (Abid et al., 2019). Farmers often interpret climate change differently from the scientific community. While scientists approach the issue through analytical and empirical frameworks, farmers draw on their cultural beliefs, social experiences, and local interactions to construct their understanding of climate change and determine appropriate responses (Thomas et al., 2019). As a result, smallholders' perceptions are largely influenced by personal experiences rather than scientific evidence (Ricart et al., 2022).

Existing literature highlights that personal beliefs and public perceptions of climate change remain critical gaps in understanding the subjective dimensions of climate awareness—gaps that can only be addressed through scientific inquiry (Wolf & Moser, 2011). Several studies indicate that most

farmers have noticed observable shifts in climate conditions (Soubry et al., 2020). For example, Fox et al. (2018) examined the role of climate change adaptation in enhancing income and food security in Ethiopia and found that farmers possess considerable awareness of climate-related changes. Nonetheless, their findings mainly reflect the experiences of large-scale farmers, overlooking smallholders who cultivate small, fragmented plots of land.

Research by Mertz et al. (2009) shows that farmers perceive climate change through indicators such as increased rainfall intensity, altered rainfall timing, frequent droughts, changes in temperature, pest outbreaks, and extreme weather events including floods, hailstorms, and strong winds. Conversely, some scholars argue that many farmers still lack sufficient knowledge and awareness of climate change (Ríos-González et al., 2013). (Singh, 2020) emphasizes that the degree of farmers' perception of climate risks influences their willingness to adopt adaptive strategies. Adaptation thus represents a localized response to climatic stresses, directly linked to farmers' awareness and understanding of climate dynamics (Below et al., 2015).

Overall, empirical evidence on farmers' understanding of climate change remains mixed, likely reflecting variations in geographical, cultural, and socio-economic contexts (Belay et al., 2022). In Uganda's rural context, more research is required to explore how smallholder farmers perceive and comprehend climate change. Globally, studies have shown that farmers' perceptions of climate variability significantly influence their responses and adaptation decisions (Arbuckle Jr et al., 2015).

2.2 Small-holder farmers' livelihoods amidst climate change

In conceptualizing the relationship between climate change and farmers' livelihoods, climate change refers to long-term alterations in temperature, precipitation patterns, and general weather conditions—mainly driven by human actions such as deforestation and greenhouse gas emissions (IPCC, 2021). Its consequences are most visible in developing regions, where agriculture forms the foundation of rural livelihoods (Niang et.al, 2014). In Uganda, where over 70% of the population engages in subsistence agriculture, variations in climate patterns have emerged as a significant threat to household incomes, food availability, and overall social well-being (NEMA, 2020). The term livelihoods encompass the range of assets, skills, and activities that people use to

sustain their living (Chambers & Conway, 1992). In rural settings such as Manafwa District, livelihoods are diverse—comprising crop cultivation, livestock keeping, small-scale trading, and casual labor exchange. However, the growing irregularity of rainfall, soil degradation, and pest infestations associated with changing climate conditions have increasingly destabilized these livelihood systems (Ongoma & Awange, 2019). While several scholars attribute livelihood vulnerability directly to climatic variability, others contend that socio-economic factors—such as land ownership systems, access to credit, and the presence of institutional support—mediate the extent of that vulnerability (Bryan et al., 2013). This ongoing debate highlights the importance of localized research, such as the current study, which examines both climatic and non-climatic influences within a specific rural context.

Smallholder farmers sustain their livelihoods through a mix of agricultural production, participation in rural labor markets, self-employment in the non-farm economy, and in some cases, migration to urban areas or abroad. Agriculture remains the dominant livelihood source in many African nations, with the majority of rural inhabitants depending on it for income and sustenance. In sub-Saharan Africa, more than 60% of the economically active population and their dependents rely primarily on agriculture for their livelihoods (Sakho-Jimbira & Hathie, 2020). Although the sector's contribution to GDP has been gradually declining, its share of total employment remains disproportionately high (Alston & Pardey, 2014). In Eastern Uganda, particularly in Manafwa District, rural livelihoods revolve around a relatively narrow set of activities, which are often short-term but combined in complex and adaptive ways.

Climate change and the rise in extreme weather conditions have eroded essential livelihood assets, capabilities, and entitlements—especially among poor and marginalized groups—forcing a reconfiguration of traditional livelihood systems. Many of these activities, including rain-fed farming, seasonal agricultural employment, pastoralism, fishing, and even tourism, are directly sensitive to climatic shifts. Gornall et al. (2010) emphasized rainfall variability as a principal driver of change, noting that fluctuations in precipitation can cause both annual and long-term variations in crop yields. In some cases, households are unable to produce adequate grain to meet their subsistence needs one year out of every three.

Empirical evidence from Eastern Uganda, and Manafwa District in particular, confirms that climate change poses a serious threat to both food and livelihood security. Additionally, factors such as population growth, changing consumption habits, and accelerating urbanization have been identified as further pressures undermining rural livelihoods (Brown et al., 2007). Climate change has even been characterized as an emerging security challenge in Africa (Brown et al., 2007), with recent projections suggesting an increased likelihood of civil conflicts linked to environmental stressors (Burke et al., 2009).

Overall, climate change negatively influences all dimensions of food and livelihood security (Connolly-Boutin & Smit, 2016). The range of livelihoods in Eastern Uganda disrupted by climatic stresses includes crop and livestock farming, fishing, agricultural wage labor, small business ventures, hawking, weaving, and construction. These impacts highlight the urgent need for targeted policy interventions and adaptive strategies to reduce vulnerability and strengthen resilience among smallholder farmers.

2.3 Climate change adaptation strategies by smallholder farmers

Adaptation to climate change has been widely examined across the globe, although research findings remain inconclusive regarding its overall effectiveness. Evidence from countries such as Kenya and Tanzania indicates that farmers employ a variety of coping mechanisms, including soil conservation, crop diversification, and agro forestry (Mwalusepo et al, 2020). In Uganda, Mugagga et al. (2021) observed that communities in the Mount Elgon region implement strategies such as terracing, contour ploughing, and tree planting to curb soil erosion and reduce water loss. However, the long-term sustainability of these interventions remains limited due to constraints such as inadequate agricultural extension services, poverty, and insecure land tenure systems. Although these adaptive measures are valuable, scholars have pointed out that many of them are reactive rather than strategic or anticipatory, and thus may not ensure sustainable resilience in the long run (Antwi-Aggyei et al., 2014) In addition, adaptation initiatives introduced by governments and non-governmental organizations often apply uniform strategies without sufficient regard for the unique socio-economic and environmental conditions of local communities, leading to uneven uptake (Twongyirwe et al., 2019) For instance, wealthier households tend to adopt improved crop

varieties and technologies more readily than resource-constrained farmers who lack access to financial or technical inputs.

Understanding adaptation therefore requires going beyond listing specific practices; it demands examining the underlying factors that determine why certain households adapt more effectively than others. Key determinants include levels of education, access to information, gender roles, social networks, and institutional support mechanisms that either facilitate or hinder resilience. Adaptation constitutes a fundamental component in the assessment of climate change impacts and vulnerability and serves as a vital policy response to climatic risks (Olmos, 2001). The issue is particularly critical in developing countries—especially in Africa—where exposure to climate shocks is high and adaptive capacity remains low (Nath & Behera, 2011). In agricultural contexts, adaptation enables farmers to sustain food production, income, and livelihoods amid fluctuating climatic and socio-economic conditions such as erratic rainfall, prolonged droughts, and volatile markets. Farmers mitigate potential damages through both tactical and strategic responses to environmental changes. According to (Mutua & Goda, 2021), adaptive strategies in agriculture encompass a broad spectrum—from technological innovations and management adjustments to institutional and policy-level interventions. Short-term adaptation practices include crop and livestock diversification, agricultural insurance schemes, adjusting planting schedules, altering crop intensity, modifying livestock management, establishing food reserves, and temporary migration to diversify income opportunities (M. R. Anwar et al., 2013). Secure land tenure and the development of land-use plans also encourage long-term investment in adaptation. Thornton and Herrero (2014) identified several long-term adaptation pathways such as breeding climate-resilient crop and livestock varieties, improving market systems, expanding irrigation and water storage infrastructure, promoting efficient water use, strengthening forecasting capabilities, enhancing institutional frameworks, and improving decision-making processes. Adaptation programs can benefit significantly from integrating lessons drawn from prior development initiatives, particularly by recognizing the contribution of indigenous knowledge systems (Chikaire & Nnadi, 2011). Yet, two major challenges hinder the incorporation of indigenous knowledge into formal climate policies: first, the lack of recognition of its importance, and second, the difficulty of harmonizing traditional knowledge with scientific frameworks (Nyong et al., 2007). Across sub-Saharan Africa, farmers have long relied on locally developed practices that reduce vulnerability

to climatic extremes. A key aspect of this resilience is the use of early warning systems that enable farmers to anticipate and respond to climatic hazards (Basher, 2006). Farmers in various regions facing harsh climatic conditions—across Africa, Asia, and Latin America—have developed or inherited intricate agricultural systems that offer practical responses to contemporary climate challenges (Bhatta & Aggarwal, 2016). For example, surveys from seven Kenyan districts revealed that most farmers perceive rising temperatures and changing rainfall patterns and respond by modifying planting decisions. However, lack of access to improved seed varieties and extension support remains a major constraint (Bryan et al., 2013).

Comparative studies show that Canadian farmers, who have better access to technology and management resources, exhibit stronger adaptive capacities (Khatri & Pasa, 2023). Research in China's Northern Plain revealed significant temperature increases with stable precipitation trends, resulting in water shortages, increased demand for food grains, and higher agricultural input costs (Fan et al., 2012). In response, farmers have adjusted planting dates and adopted water-saving irrigation methods (Getachew et al., 2021). Similarly, household surveys in Punjab Province, Pakistan, show that farmers adapt by shifting planting schedules, altering crop varieties, increasing fertilizer use, and planting shade trees, although limited budgets and information access remain key barriers (F. Anwar et al., 2023).

These findings suggest that farmers' perceptions and adaptation behaviors vary widely across geographical and cultural contexts, even within the same climatic zones. Consequently, it is difficult to generalize results from large-scale studies to smaller communities, where local perceptions and adaptive responses may differ substantially.

According to Baffour-Ata et al. (2023), farmers in Ghana's Sekyedumase District employ several adaptation measures such as altering crop types, adopting short-season varieties, changing planting periods, and diversifying crops. In Lesotho, adaptation approaches include water harvesting, conservation tillage, trench and keyhole gardening, agro forestry, and the use of traditional pest control methods (Mhlanga, 2004). Similarly, women farmers in Peru draw on indigenous knowledge systems passed down through generations to guide their responses—delaying planting when rains are late, rotating crops, cultivating native species, and seeking off-farm employment during adverse seasons others (Altieri & Nicholls, 2017). In Ethiopia and South Africa, common

adaptation strategies include tree planting, crop diversification, and adjusting planting times (Bryan et al., 2009).

2.4 Theoretical Perspectives on Climate Change and Livelihoods

The Sustainable Livelihoods Framework (SLF) developed by the Department for International Development (DFID, 2000) is widely used to examine how various forms of capital—namely natural, physical, financial, human, and social—affect the capacity of households to manage and recover from shocks. The framework emphasizes that vulnerability stems not only from environmental conditions but also from socio-economic circumstances. Nonetheless, some scholars contend that the SLF overlooks critical elements such as power relations, governance structures, and historical inequalities that influence communities' adaptive capacity (Scoones, 2015). An alternative analytical approach is the Vulnerability and Adaptation Framework, which highlights three main dimensions: exposure, sensitivity, and adaptive capacity (Smit & Wandel, 2006). This model provides a useful perspective for understanding how the effects of climate change differ among social groups. However, it has been critiqued for giving insufficient consideration to long-term livelihood transitions—particularly in situations where adaptation entails shifting away from agriculture as the main economic activity.

Considering the strengths and limitations of these two frameworks, combining their insights offers a more comprehensive analytical foundation for this study. Such an integrative perspective facilitates an understanding of both the physical manifestations of climate change and the socio-economic dynamics that shape adaptation outcomes among smallholder farmers in Manafwa District.

2.5 Identified Gaps in the Literature

A critical review of the existing literature reveals several areas that remain underexplored Limited local-level studies: The majority of Ugandan research focuses on the wider Eastern Region, with few investigations concentrating specifically on Manafwa District. Overemphasis on agricultural yields: Previous studies tend to assess the impact of climate change primarily through crop production metrics, overlooking the contribution of off-farm employment and social networks that

strengthen household resilience. Insufficient attention to farmers' perspectives: There is a notable lack of qualitative research capturing farmers' lived experiences, perceptions, and adaptive strategies in their own words. Weak institutional and policy analysis: Few studies have examined how agricultural extension systems, cooperatives, and government programs shape the success or failure of adaptation efforts.

2.6 Summary and Critical Reflection

In conclusion, the reviewed scholarship demonstrates that climate change presents major threats to smallholder farmers, particularly through yield reductions, land degradation, and fluctuating income levels. Yet, most of the available research remains descriptive, failing to adequately link climatic stresses to the broader social and economic realities faced by rural households.

By centering on Manafwa District, this study provides a locally grounded and qualitative perspective that integrates farmers' perceptions, livelihood experiences, and adaptation practices within the framework of sustainable livelihoods. In doing so, the research addresses critical empirical gaps and challenges the prevailing notion that the impacts of climate change are homogeneous across farming communities.

CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter outlines the methodological framework adopted in the study. It explains the research design, target population, sampling procedures, data collection techniques, analytical approaches, ethical considerations, and study limitations.

3.1 Research design

A descriptive survey research design was employed to systematically collect and analyze data reflecting the existing conditions and experiences of smallholder farmers in Manafwa District. The design facilitated efficient data collection from a large number of participants, allowing comprehensive insights into the characteristics and behaviors of the target population. A mixed-method approach was utilized, integrating both quantitative and qualitative data. This approach improved data validity through triangulation and complemented numerical findings with narrative perspectives.

3.2 Study Area Description

3.2.1 Location

This study was conducted in Manafwa District, located in the Eastern Region of Uganda. It shares borders with Bududa District to the north, Kenya to the east and southeast, Tororo District to the southwest, and Mbale District to the west (Oyana et al., 2015)

3.2.2 Rainfall

Manafwa District experiences a bimodal rainfall pattern, with the major rainy season occurring from March to June and a shorter, less intense season between September and November. Dry periods typically occur between June and July and again from December to March. The district's relatively high and reliable rainfall supports intensive agricultural activities, which are central to the local economy and contribute significantly to Uganda's national food basket (Okoth et al., 2024). Average annual rainfall in Manafwa District is approximately 1,500 mm. Due to erosion, some hilltops exhibit exposed rock outcrops, while sediment deposition has created deeper soil

profiles in valley areas (Sebuliba et al., 2022). Manafwa District faces persistent soil erosion challenges, though their full extent has not been quantified. The broader Mount Elgon region, encompassing Manafwa, Bududa, and Mbale Districts, is among Uganda's most climate-vulnerable areas and has previously experienced severe landslides, notably the 2010 event (NEMA, 2019; OPM, 2015)

3.2.3 Soils

Since Manafwa district falls on the slopes of Mt. Elgon, it is endowed with fertile soils that are a result of volcanicity and therefore volcanic ash. This soil is a clear indication that when volcanic action took place, the volcanic ash overlaid the original parent rock. The hills due to erosion are now having rock outcrops while the wetlands and valleys due to deposition are having thick profiles. Soil texture varies across the district; upland areas contain loose, easily saturated soils, whereas valley bottoms feature dense clay soils overlain by eroded sediments from surrounding hills, leading to notable changes in vegetation and land use (Sebuliba et al., 2022).

3.2.4 Vegetation

Manafwa District supports a wide range of vegetation types, largely influenced by variations in climate, altitude, and topography. Vegetation distribution changes gradually with altitude, reflecting corresponding variations in temperature and rainfall patterns. Consequently, vegetation transitions from tropical savannah and grassland in the lowlands to tropical forest in mid-altitudes, and finally to alpine vegetation near the mountain summit. Dominant vegetation types include grasslands, forest patches, and wetland species. Bamboo (a locally valued plant) characterizes the temperate zones of Mount Elgon (Sebuliba et al., 2021).

3.2.5 Drainage

The district's drainage pattern is influenced by its geological composition, including extensive underground aquifers that regulate groundwater flow. From the physical appearance, the district has two main surface drainage patterns i.e. dendritic and radial as a result of volcanic processes (Bamutaze et al., 2014).

3.2.6 Relief

The terrain of Manafwa District comprises three main zones: lowland plains, upland plateaus, and mountainous highlands. The lowland plain extends generally west-southward, stretching from Mbale District toward Tororo District. Average elevation exceeds about 1,800 meters, with several ridges and peaks rising higher (Mugagga et al., 2012).

3.2.7 Demography

According to the 2017 district statistics, Manafwa District has an estimated population of about 353,825 people—49.2 percent male and 50.8 percent female—with an annual growth rate of 2.5 percent and a population density of approximately 661 persons per square kilometer (Namugaya, 2017). The district contains roughly 72,800 households, each averaging 4.8 members, and has an urbanization rate of around 14.5 percent (Namugaya, 2017). About 85.5 percent of residents (approximately 302,541 individuals) live in rural areas. Household members constitute 99.7 percent of the total population, leaving 0.3 percent as non-household residents (Namugaya, 2017)

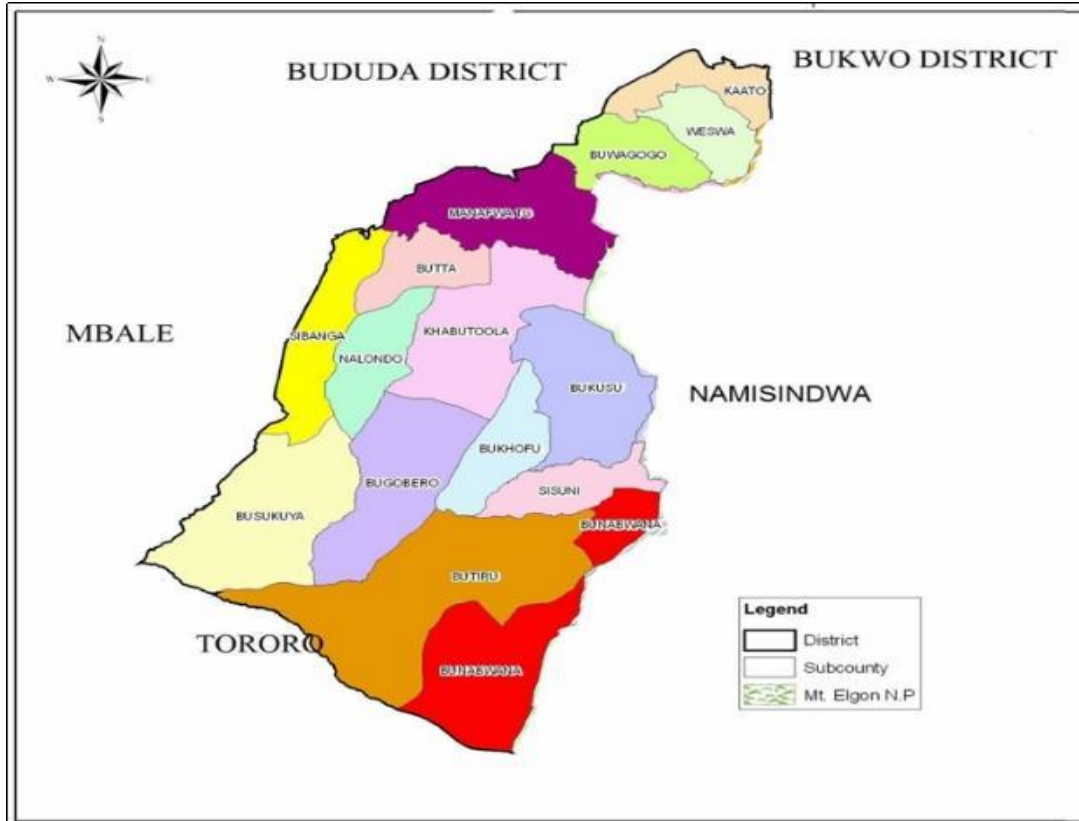


Figure 3:1. Administrative units of Manafwa (source, Manafwa District statistical Abstract 2019-2020)

3.3 Study population

A study population refers to the complete group of individuals or elements sharing specific characteristics that are relevant to the research objectives and from which generalizations are drawn (Monarchi & Puhr, 1992). This is an aggregate or totality of objects, or individuals, having one or more characteristic(s) in common that are of interest to the researcher and where inferences are to be made (Monarchi & Puhr, 1992). In this research, the population consisted of all smallholder farmers residing within the designated study area in Manafwa District. The target population comprised all the 72815 households (Batte et al., 2024).

3.4 Sample size

A sample refers to a subset of participants drawn from the target population that adequately represents its characteristics for the purposes of analysis (Saunders & Townsend, 2018) . The sample size was determined using Slovin’s formula, which provides an efficient approach for estimating sample size from a known population when the margin of error is specified. Based on district data reported by (Batte et al., 2024), Manafwa District contains approximately 72,815 households. From this population, a representative sample of 398 farmers was selected for the study (Tejada & Punzalan, 2012).

Using: $n = N / (1+Ne^2)$

n = sample size

N = POPULATION

e = margin of error

Taking a 95% confidence interval of +/- 5%

$100 - 95 = 5\%$

$$= 0.05$$

Therefore, $n=72815 / (1+72815*0.05^2)$

$$n=397.8$$

$$n=398$$

3.5 Sampling Procedure

The study employed a combination of sampling techniques suited to the nature of the research objectives and population characteristics. Manafwa District was chosen purposively due to its high exposure to climate-related hazards and the predominance of smallholder farming as the district's principal economic activity (Batte et al., 2024). Stratified random sampling was applied to select two sub-counties—Kato and Lwanjusi—representing areas of high and low exposure to climate change risks, respectively. Within each selected sub-county, three parishes were chosen through simple random sampling to ensure fair representation across communities. Key informants were identified purposively based on their expertise, while systematic random sampling was employed to select participating households. The use of randomization improved the validity and reliability of the data by minimizing selection bias and controlling for external influences.

3.6 Data Types and Sources

Both primary and secondary sources of data were utilized in this study to ensure comprehensive information coverage. Primary data collection involved household surveys, key informant interviews, and focus group discussions (FGDs). Data were gathered from 398 household heads or their representatives through face-to-face interviews and FGDs. Key informants included local political leaders, agricultural officers, and disaster management personnel from the selected climate-vulnerable areas.

Secondary data were obtained through document review, covering academic journal articles, government reports, online databases, newspapers, and publications by local, bilateral, and multilateral organizations.

3.7 Data Collection Methods and Tools

Primary data were gathered through household surveys and key informant interviews conducted by the researcher with the support of four trained research assistants. A total of 398 household heads or their representatives were interviewed in person to obtain firsthand information relevant to the study objectives.

For Objectives 1 and 2, data were collected through a household survey that employed semi-structured questionnaires containing both closed- and open-ended items. To facilitate efficient data collection and minimize entry errors, the questionnaire was digitized using the EpiCollect5 mobile data collection platform.

Data addressing Objective 3 were obtained through key informant interviews and FGDs. Participants responded to open-ended questions, with responses audio-recorded and complemented by written notes for accuracy. To ensure validity and reliability, the questionnaire was pretested in a non-sample area, and necessary adjustments were made prior to final administration.

3.8 Data Analysis

Quantitative data addressing the first and second objectives were analyzed using descriptive statistical methods, including frequency tables, percentages, graphical presentations, and Spearman's rank correlation to explore relationships among variables. Quantitative data entry, coding, and analysis were conducted using Stata version 16, which facilitated efficient data management and statistical computation. Qualitative data for the third objective were analyzed thematically through content analysis. This involved coding responses, categorizing similar ideas, and synthesizing them into overarching themes to capture participants' perspectives.

3.9 Operational Definition of Variables

This section outlines the principal variables of the study and describes how each was defined, conceptualized, and measured. Operationalization allows abstract constructs—such as climate change, livelihoods, and adaptation strategies—to be converted into measurable indicators for

systematic observation and analysis. The study comprised independent, dependent, intervening, and control variables that interact to explain the research relationships. The independent variable for this research was climate change, whereas the dependent variable was the livelihood outcomes of smallholder farmers. Adaptation strategies were conceptualized as intervening variables mediating the relationship between climate change and farmers' livelihoods. Socioeconomic characteristics—including age, education level, and farm size—functioned as control variables to account for individual differences that could influence livelihood outcomes..

Type of Variable	Variable	Operational Definition	Indicators / Measures	Data Collection Methods
Independent Variable	Climate Change	Long-term variation in temperature, rainfall, and the frequency of extreme weather events in Manafwa District.	Changes in rainfall onset and cessation; Frequency and severity of droughts and floods; Increase in average temperature; Incidence of crop pests and diseases associated with climate variability.	Key informant interviews; Household interviews and FGDs.
Dependent Variable	Farmers' Livelihoods	The means by which smallholder farmers sustain their lives through	Crop yield levels; Household income; Food availability and security;	Household interviews; FGDs.

		agricultural and related activities.	Livestock ownership; Non-farm employment or income diversification.	
Intervening Variable	Adaptation Strategies	Actions undertaken by farmers to mitigate or cope with the adverse impacts of climate change.	Use of improved crop varieties; Soil and water conservation practices (terracing, contour ploughing, mulching); Livelihood diversification; Tree planting and agroforestry; Irrigation or water harvesting techniques.	Field observation; Focus group discussions; Key informant interviews.
Control Variables	Socio-Economic Factors	Farmers' background characteristics that influence adaptation and	Age, gender, and education level; Farm size and land ownership;	Household survey

		livelihood outcomes.	Access to credit and extension services; Membership in farmer groups.	
--	--	----------------------	--	--

Framework of this study illustrates the relationship between the major variables. Climate change (independent variable) is expected to influence farmers' livelihoods (dependent variable), either positively or negatively. However, the nature and magnitude of this effect are influenced by the adaptation strategies adopted by farmers (intervening variable). Socio-economic characteristics serve as control factors that may shape both adaptation capacity and livelihood outcomes.

3.10 Ethical considerations

The researcher obtained a letter of introduction from the Head of Department at Busitema University detailing the purpose and nature of the study to be conducted which the researcher presented to the respective authorities in the study area. The names of respondents were not required during data collection. Consent was sought from the participants before holding each interview. The researcher also ensured confidentiality of the data collected by using it for only the intended purpose, which was clearly stipulated to the respondent in the introduction section of the questionnaire.

3.11 Limitations and delimitations of the study

Despite the relevance and significance of the study, a number of limitations were encountered; this influenced the depth of the study plus the scope. This study was limited to Manafwa and to smallholder farmers and in such, the findings may not apply to other districts or regions in Uganda. Therefore the geographical scope was narrow. The study was characterized with weather variations in the form of rainfall that resulted in damage to the paper questionnaires and delayed the research assistants to reach the sampled villages. However, the researcher ensured that all the enumerators have umbrellas and gumboots. The researcher also targeted months of low rainfall basing on predictions by the Uganda Meteorological Authority. Thirdly, due to limited resources and time

constraints, the number of interviews were small hence limiting statistical generalizability of results, in addition since climate change effects are long term and yet the study was conducted in a short period this made it difficult to fully capture seasonal and yearly variations.

CHAPTER FOUR: DISCUSSION OF RESULTS

This chapter presents and discusses the findings of the study.

4.1 Socio-economic demographic characteristics of the respondents

The results indicate that most of the household heads in the study area are male (61.1%) and the largest percentage of the respondents encountered belonged to the (40-59) years age bracket followed by those that belonged to (25-39) years age bracket. This could be attributed to the school attendance since data was collected during school time. The majority of the respondents were Anglicans (35.9%) while Catholics made (33.4%). Religion is an important factor when it comes to uptake of technology. With regard to marriage, the highest percentage of the respondents interviewed was married (92.5%). Very few singles or unmarried respondents were encountered at their homes because of culture. After circumcision, the boy gets a wife despite being less than 18 years. The high number of respondents being Iteso (35.2%) in the district hoped to be dominated by Bagisu was because a lot of sampling was done in Lwanjusi Sub County which is very close to Tororo, a district occupied mainly occupied by the Iteso and Japadhola. The number of respondents sampled from Kato was less than that which was expected because there has been relocation of Bagisu from Kato Sub County to Bulambuli district by government since the area is highly vulnerable to mudslides. Majority of the respondents had primary level of education (64.8%). The main occupation of the respondents was farming (92.5%). Saving is one the ways of getting ready

for the uncertainties. However, the results show that 57.5% of the respondents encountered did not save any money. Results show that most of the respondents own land (61.1%). However, there were some respondents who hired land. Most of the respondents had been in farming for over 21 years (56.5%). Farming experience is very vital especially in determining the level of adaptation. Most of the farmers in the area use rudimentary tools to prepare the land for agricultural activities. Results showed that the largest number of farmers use hand hoe (66.6%). Very few farmers use herbicides since they are expensive.



Figure 4:1. A Farmer practicing second ploughing using oxen before planting

The majority of the respondents have lived in the area for more than 12 years (76.1%). The duration in the area sometimes helps in making the comparison between the current and the past climatic conditions.

4.2. Smallholder farmers' perception and understanding of local climate change

Majority (97.9%) of the respondents had witnessed change in climate of their area. This proves that climate change is very evident in the area.

“The weather is ever changing in different months or weeks. It may be heavy in raining and we have just not too much sunshine but when we are experiencing lot of rain during that month”, (Respondent from mixed FGD, Kato Sub County).

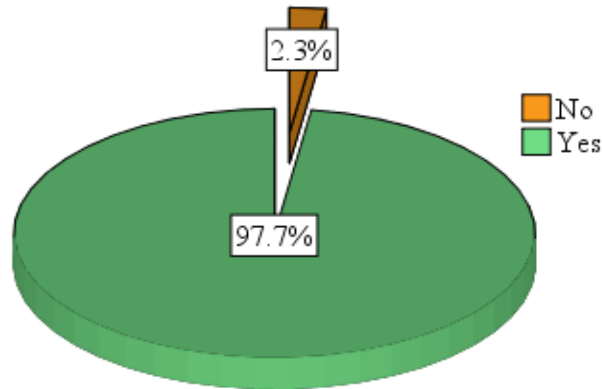


Figure 4:2. Pie chart showing the percentage of respondents who had witnessed climate change

The community perceived deforestation to be the main contributor to change in climate (29.6%), (See Table 1). However, results show that there were a proportion of respondents who did not know the causes of climate change (10.8%). This threatens the move to mitigating the impacts of climate change as such people will continue jeopardizing the efforts intended to fight climate change.

		Count	Column N %
C.C_Cause	Deforestation	118	29.6
	Developments	74	18.6
	Encroachment on wetlands	24	6.0
	I dont know	43	10.8
	Industrialization	25	6.3
	Others	12	3.0
	Over population	63	15.8
	poor farming methods	39	9.8

Table 4.1: Perception of respondents on the causes of climate change

Information from KIIs clearly agreed that the major cause of climate change is deforestation especially for firewood and charcoal as confirmed by the quotation below;

“In fact, according to what the scientists tell or what we have experienced we have been having a lot of trees being cut down. Like on this hill and the other hill on the other side we used to have a lot of trees on them but because of

firewood a lot of trees have been cut down for charcoal making, firewood so there has been a lot of trees cutting”, (Agricultural Officer, Kato sub county).

Time spent in the area significantly ($p=0.089$) influenced the ability to notice the change in climate. People who have spent a lot of time in the area could easily compare the climatic factors over time and tell whether there has been a change or not. Secondly, occupation of the respondent also showed a significant relationship ($p=0.021$) with the chance of noticing the change in climate. It was easy for the farmers to tell whether there has been a change in climate since most of the agricultural activities are rain-fed. Thus, any change in climate affects them directly.

Pearson Chi-Square Tests

		C.C_noticed
farmer group Membership	Chi-square	2.770
	Df	1
	Sig.	0.096*
Sex	Chi-square	0.122
	Df	1
	Sig.	0.727
Age	Chi-square	1.758
	Df	3
	Sig.	0.624
Religion	Chi-square	2.181
	Df	4
	Sig.	0.703
Marital_status	Chi-square	6.201
	Df	3
	Sig.	0.102
Tribe	Chi-square	1.998
	Df	7
	Sig.	0.960

Education	Chi-square Df Sig.	9.909 3 0.019*
HH_Size	Chi-square Df Sig.	.921 4 0.922
Occupation	Chi-square Df Sig.	7.710 2 0.021*
Have_Personal_Savings	Chi-square Df Sig.	.314 1 0.575
Time_spent_Area	Chi-square Df Sig.	2.887 1 0.089*
Time_spent_Farming	Chi-square Df Sig.	1.691 1 0.193

*. The Chi-square statistic is significant at the 0.1 level.

Table 4:2. Relationship between demographic factors and the possibility to notice a change in climate

Findings show that the farmers perceive climate change to be the increase in rainfall, drought and floods. However, the number of respondents attributing landslides to climate change is very small.

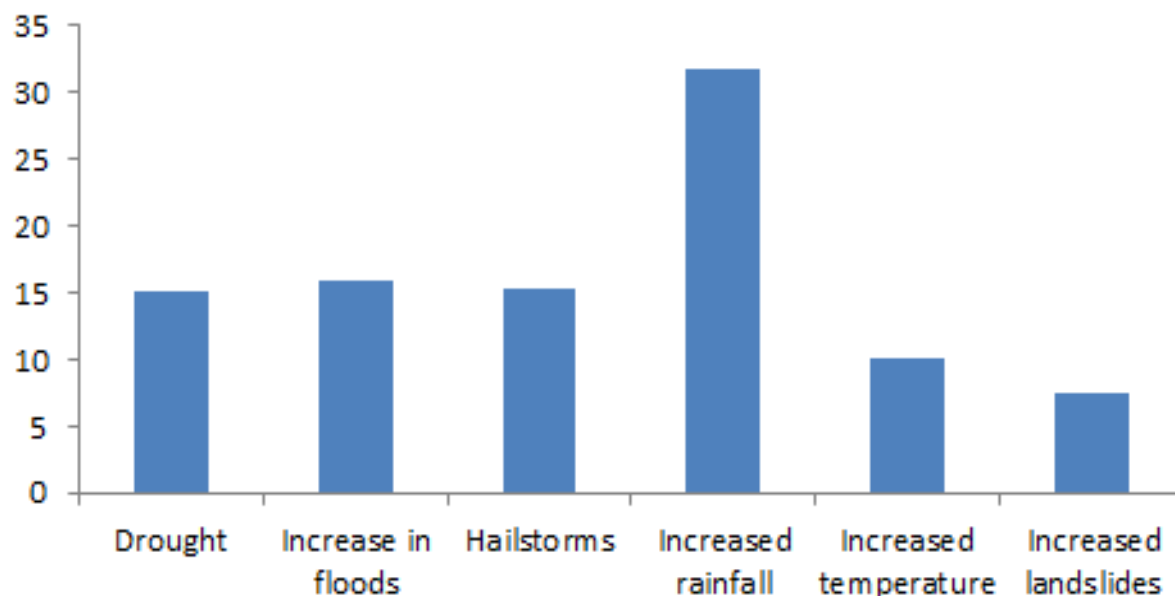


Figure 4:3. Perception of respondents on the major climatic changes noticed

Manafwa district experiences a number of climate change related hazards. The largest percentage of respondents (91.0%) agreed when asked about the change in weather and whether they had noticed. Changes in the weather have been noticed in form of change in rainfall (34.5%), and change in flooding (Table 3).

Weather Change notices	Count	Column N %
change in drought periods	42	11.7
change in flooding	99	27.3
Change in rainfall	125	34.5
change in temperature	96	26.5

Table 4:3. Perceptions of the respondents on the major weather changes noticed

These occur in different periods and months of the year. This is confirmed by the quotations below;

“There is a lot of rainfall in May and high temperatures from the month January, February like that, January and February”, (Respondent from mixed FGD, Kato Sub County).

However, information from FGDs reveal that excessive rainfall and hailstorms are sometimes experienced during the months of September, October, November and sometimes April as confirmed by the quotation below;

“Sometimes we experience heavy rainfall and hailstorms in September, October and November, sometimes it comes in that season or that month, even during the month of April”, (Respondent from mixed FGD, Kato Sub County).

The majority (85.2%) of respondents interviewed said they had noticed change in temperature Error! Reference source not found.).

The survey findings further reveal that out of all the respondents who had witnessed changes in temperature, 55.5% indicated that the temperature has increased through time while only 44.5% reported the temperature to be decreasing.

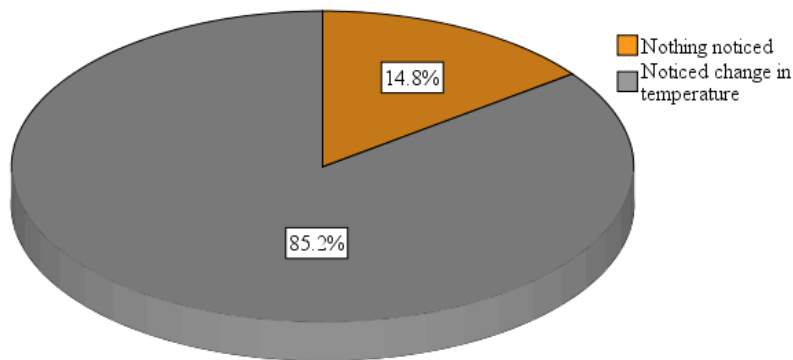


Figure 4:4. Perception of respondents on changes in temperature

The time spent in the area ($p=0.009$,) and occupation ($p=0.000$) significantly explained the possibility of noticing the change in temperature. It was revealed that whenever there is a change in temperature, farmers’ crops like beans are greatly affected by the high temperatures. This is because high temperatures cause a lot of evaporation of moisture from the soil leading to water stress to the crops. On the other hand, respondents who had been in the area could easily make

comparisons of the current and past, and thus were able to detect whether there was a change in temperature and the nature of the change.

Pearson Chi-Square Tests

	Land ownership	Time spent Farming	Time spent Area	Occupation	Education	Tribe	Marital status	Religion	Age	Sex
Chi-square	4.700	1.535	6.864	20.938	7.054	5.554	.642	2.496	4.147	.080
noticeddf	2	1	1	2	3	7	3	4	3	1
Sig.	0.095	0.215	0.009*	0.000*	0.070	0.593	0.887	0.645	0.246	0.777

*. The Chi-square statistic is significant at the 0.05 level.

Table 4:4. Relationship between times spent in the area and the possibility to notice climate changes

Majority of the people (85.9%) indicated that the rainfall received in the area has changed over time **Error! Reference source not found.**)

Evidence of change in rainfall	Count	Column N %
No	56	14.1
Yes	342	85.9

Table 4:5. Perception of the respondents about changes in rainfall received

It was revealed that the fluctuation in the amount of rainfall received in the area has had many consequences on livelihood and biodiversity. Results indicate that those who reported to have notices changes in rainfall cited variations in rainfall amounts (43.0%), variation in rainfall durations (20.2%), variation in rainfall intensity (27.8%), variations in rainfall seasons (9.0%).

The largest percentage (92.2%) of the respondents revealed that there were high incidences of flooding in the district. The rest of the respondents revealed that there were no flood incidences in the study area. When the respondents were asked to describe the changes, they had noticed about floods, the majority (68.4%)(**Error! Reference source not found.**) indicated that they had witnessed an increase in flood occurrence and severity.

Perception about flooding events	Count	Column N %
Changed periods of flood occurrences	6	1.6
Changed periods of flood occurrences	46	12.5
Increased flood occurrences and severity	251	68.4
Others	1	0.3
Reduced flood occurrences and severity	63	17.2

Table 4:6. Perception of respondents about the change in flooding events

Findings also reveal that 78.1% of the respondents had noticed drought incidences. The proportion of respondents who did not notice any change in drought was 21.9(Error! Reference source not found.).

The perception of respondents was sought on the nature of the drought notices in the area. However, results show that a largest percentage of the respondents had noticed increase in the drought intensity (42.8%)(See **Error! Reference source not found.**).

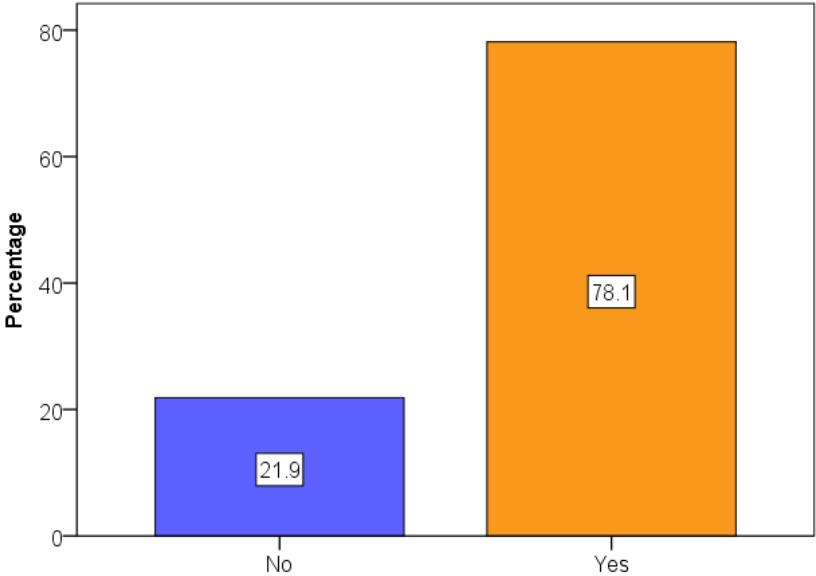


Figure 4:5. Perception of the respondents on drought notices in the study area

A number of factors uniquely influenced the possibility of noticing the changes in drought. Sex of the respondents significantly influenced the possibility of noticing drought (p= 0.000). It was revealed that men because they cultivate for commercial purposes could easily notice the change

in drought. The worry that married respondents had about feeding their families if drought affected crops and thus significantly (0.000) noticed any changes in drought.

Pearson Chi-Square Tests

	Time spent Farming	Time spent Area	Sex	Age	Religion	Marital status	Tribe	Education	HH Size	Occupation
Chi-square	4.801	4.047	20.922	34.097	69.315	39.970	110.653	8.706	23.171	7.702
df	4	4	4	12	16	12	28	12	16	8
Sig.	.308	.400	.000*	.001*	.000*	.000*	.000*	.728	.109	.463

*. The Chi-square statistic is significant at the .05 level.

Table 4:7. Relationship between drought notices and demographic factors

Results show that excess temperature in the area of study is experienced mostly in January (46.7%)(See **Error! Reference source not found.**). Very hot temperatures transit from December and intensify in January. Farmers often use this period to prepare their fields.

Month	Frequency	Percent	
Valid	Not sure	37	9.3
	April	3	1.3
	December	108	27.1
	February	46	11.6
	January	182	45.7
	June	2	0.5
	March	3	0.8

	None	14	3.5
	November	1	0.3
	September	2	0.5
	Total	398	100.0

Table 4:8. Months of excess temperatures

Excess rainfall is received in the months of May as revealed by the highest number of respondents (56.1%) and April (16.1%)**Error! Reference source not found..**

	Month of the year	Frequency	Percent
Valid	April	65	16.1
	August	5	1.3
	July	37	9.3
	June	54	13.6
	March	11	2.8
	May	223	56.1
	September	3	0.8
	Total	398	100.0

Table 4:9. Months of the year in which excess rainfall is noticed in the study area

However, it was revealed that there was uncertainty in the rainfall received. Respondents revealed that there were also cases of excess rainfall storms, and they occur most in May (46.0), the month with the highest amount of rainfall, and June (26.9%)**Error! Reference source not found..**

	Month of the year	Frequency	Percent
Valid	April	47	11.9
	August	4	1.0
	February	1	.3
	July	39	9.8
	June	107	26.9
	May	183	46.0
	N/A	1	.3
	Total	398	100.0

Table 4:10. Months of the year in which excess rainstorms are noticed in the study area

The windstorms were reported to be excess in the months of January when there is little or no rainfall (23.6%) and in the month of May (23.1%)

		Frequency	Percent
Valid	April	62	15.6
	August	21	5.3
	December	18	4.5
	February	9	2.3
	January	94	23.6
	July	3	.8
	June	48	12.1
	March	47	11.8
	May	92	23.1
	November	2	.5
	September	2	.5
	Total	398	100.0

Table 4:11. Months of the year in which excess windstorms are noticed

With reference to the month of May, the existence of windstorms indicates rainfall is sometimes destructive.

The sandstorms are mostly prevalent in the dry months of January (32.7%) and February (25.1%) (See **Error! Reference source not found.12**).

		Frequency	Percent
Valid	April	27	6.8
	August	4	1.0
	December	59	14.8
	February	100	25.1
	January	130	32.7
	July	7	1.8
	June	6	1.5
	March	34	8.5
	May	26	6.5
	None	5	1.3
	Total	398	100.0

Table 4:12. Months of the year in which severe sandstorms are noticed in the study area

The largest percentage of the respondents revealed that severe droughts are received mostly in the month of January (44.7%) and December (27.1%) and partly February **Error! Reference source not found..**

Months of the year	Frequency	Percent
Valid August	4	1
December	109	27.1
February	60	15.4
January	178	44.7
March	3	0.8
None	36	9
November	2	0.5
September	6	1.5
Total	398	100

Table 4:13. Months of the year in which excess droughts are noticed in the study area

Severe flash floods occur mostly in the month of May (46.3%) and in June (32.4%). May is a month of excess rainfall in the area and thus associated with high levels of flash floods from R. Nangilima in Lwanjusi S/C(See**Error! Reference source not found.**).

Months of severe flash floods	Frequency	Percent
Valid April	1	.3
August	19	4.8
July	3	.8
June	35	8.8
May	129	32.4
March	1	0.3
None	184	46.3
September	6	1.5
Total	20	5.0
	398	100.0

Table 4:14. Months of the year in which excess droughts are noticed in the study area

4.3 Effects of Climate Change on smallholder farmers' livelihoods

The results show that the largest number of the respondents (99.2%) indicated that climate change affects the livelihood of the people.

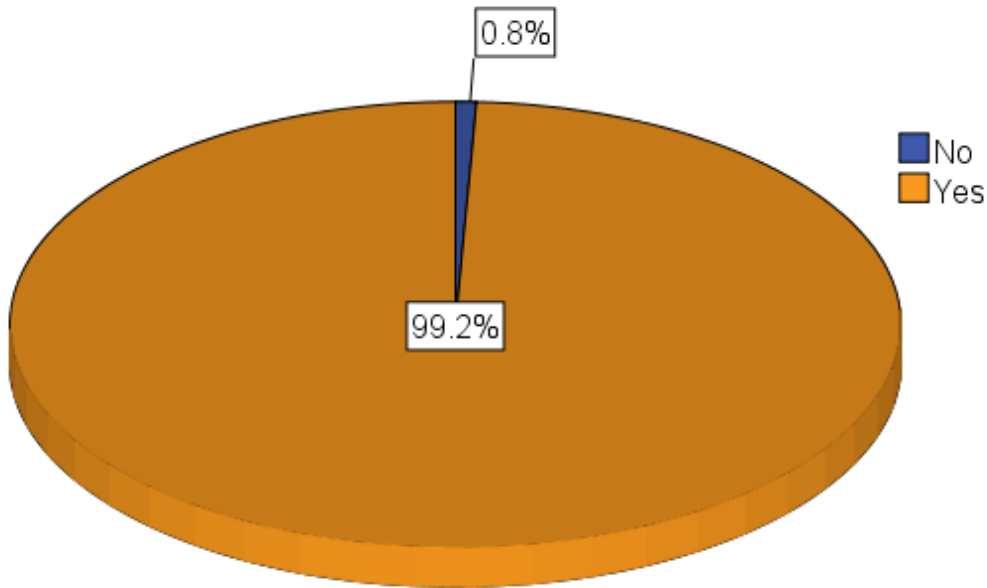


Figure 4:6. Perception of respondents on the effects of climate change on livelihood

Climate change has had an effect on water availability for crop production as a high percentage of farmers indicated that the impact was high (43.5%)(See **Error! Reference source not found.**).

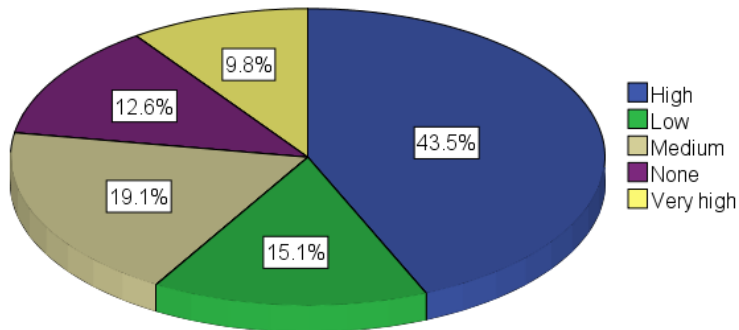


Figure 4:7. Effects of climate change on water for crop production

Respondents who noticed drought significantly associated it to the lack of water for crop production (P=0.014).

Pearson Chi-Square Tests

	Temp_noticed	R/F_noticed	Drought_noticed	Flood_noticed
Chi-square	1.953	9.798	12.461	3.110
EFF_C.C_water_Crop_Pdn Df	4	8	4	4
Sig.	.744	.280	0.014*	.540

*. The Chi-square statistic is significant at the .05 level.

Table 4:15. Relationship between climate changes noticed and water for production

A large percentage of respondents reported climate induced diseases (88.9%) (See **Error! Reference source not found.** below).

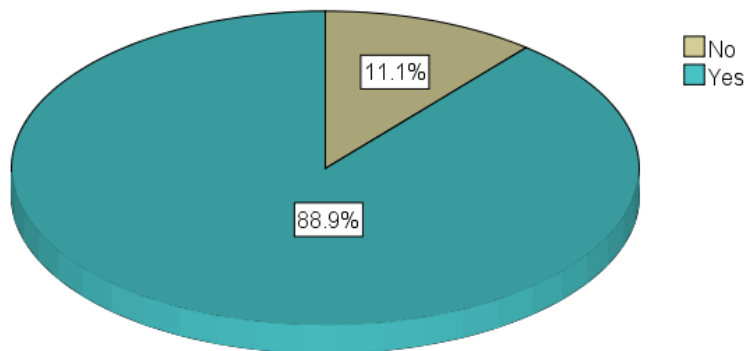


Figure 4:8. Perception of respondents on diseases induced by changes in climate

The most common diseases include banana diseases (bacterial wilt), yellowing, cassava mosaic, leaf spot, maize streak disease, leaf rust, coffee wilt, dumping off.

There was a significant relationship between flooding events and increase in crop diseases (p=0.000). Oxygen deficiency as a result of flooded conditions predisposes crops to infection by root rot pathogens. This signals that the farmers working on the agricultural fields that are highly vulnerable to flooding need to drain off excess water.

Pearson Chi-Square Tests

		Temp noticed	R/F noticed	Drought noticed	Flood noticed
C.C_Crop_Disease_Inc	Chi-square	.442	5.287	.286	26.147
	df	1	2	1	1
	Sig.	.506	.071	.593	0.000*

*. The Chi-square statistic is significant at the .05 level.

Table4:16. Relationship between flooding events and increase in crop diseases

Almost all the respondents agreed when asked about the emergence of pests (99.2%). Only 0.8% had not witnessed climate induced pests. The major crop pests mentioned were; the fall armyworms (44.2%), grasshoppers (23.4%), butterflies (6%), caterpillars (4.5%), twig borers (0.3%), Banana weevils (0.5%), Rodents (8%). Whereas the major crop diseases mentioned were; Banana bacterial wilts (32.4%), Cassava mosaic (37.7%), dumping off (2.5%), Leaf rust (1%), leaf spot (13.3%) and maize streak virus (3.3%).

The fact that climate change led to increased pests and diseases as confirmed by the quotation below;

“Before we got to witness climate change at a high level, some pests were not common, but now we see them. Fall armyworm, which affects the maize, it is common now. We look at the cassava mosaic is very common and rampant now, this area, they grow a lot of cassava but the mosaic has become a big problem and also few people who have planted bananas, there is a lot of Banana Bacterial Wilt. So the prevalence of pest and disease has been very high now” (Agricultural Officer, Kato Sub County). Water stagnation in the field due to floods provide breeding ground for crop pests like fall army worm in cereals like Maize.

Perception of the respondents on the impact of change climate on crop yield was sought. However, the largest proportion (97.7%) of the respondents revealed that climate change had an impact on the growing seasons.

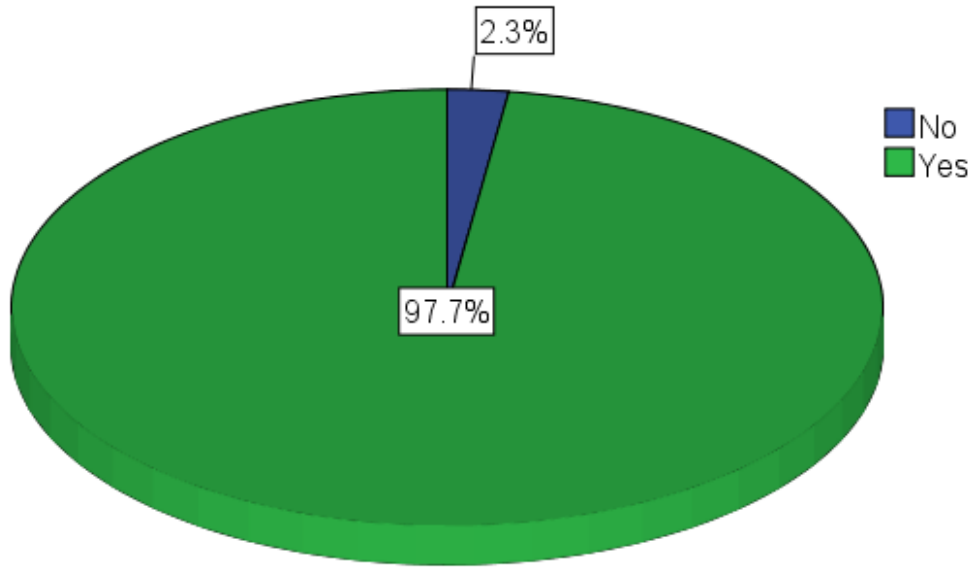


Figure 4:9. Perception of respondents on the impacts of climate change on crop yields

Respondents revealed that the seasons are not predictable. It was revealed that there have been some years where people have even had three growing seasons, and other years with one season (especially when there is a prolonged drought spell). Further analysis showed that the seasons have reduced as revealed by 72.9% of the respondents. Only a small proportion of the respondents reported an increase in the growing season (27.1%).

Pearson Chi-Square Tests

	Temp noticed	R/F noticed	Drought noticed	Flood noticed
Chi-square	10.017	12.053	.760	.006
EFF_C.C_Crop growing season				
Df	1	2	1	1
Sig.	0.002*	0.002*	.383	.939

*. The Chi-square statistic is significant at the .05 level.

Table 4:17. Climatic changes noticed in the study area and their significance to the crop growing season

Majority of the people indicated that the change in climate has affected the market for farm produce (87.2%) (See **Error! Reference source not found.**). This is because crop diseases are prevalent during excess rainfall hence reducing the quality of the produce which in turn reduces the market

price. Results show that the market for farm produce has decreased as revealed by the majority of the respondents (63.1%).

		Frequency	Percentage (%)
Valid	No	51	12.8
	Yes	347	87.2
	Total	398	100.0

Table 4:18. Effect of climate change on farm markets

Results show that the highest percentage of the respondents indicated that climate change has had an impact on the quality of agricultural produce (97.7%) (See **Error! Reference source not found.**). In consensus, results from the key informants and FGDs showed that the quality of crops especially for maize and bananas reduced due to drought and hailstorms as supported by the quotation below;

“Secondly, the quality of crops has reduced look at the maize, the quality of maize that is coming out has a lower quality than it had before. And also bananas have been affected by hail storm. It becomes difficult to sell affected bananas at same price with the banana which has not been affected by the hail storms. So climate change has reduced the yield and also reduced on the quality of crop being produced. So, generally the cost of living has increased” (Agricultural Officer, Kato Sub County).

Reduced crop quality		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	9	2.3	2.3	2.3
	Yes	389	97.7	97.7	100.0
	Total	398	100.0	100.0	

Table 4:19. Effect of climate change on crop quality

Perception of the respondents was sought on the impact of climate change on soil fertility (99.0%) **Error! Reference source not found.** Excess temperature and flooding could have profound effects on the living conditions of the soil micro and macro-organisms that would contribute

greatly to soil fertility. Majority of the respondents (97.7%) indicated that the change in climate had decreased soil fertility.

In agreement information from FGDs and KIIs revealed that climate change through the outcome hazards has led to a reduction in soil fertility. Reduced soil fertility was confirmed by the quotation below;

“The soil fertility has also gone low because for us we never used to apply fertilizers, but right now if you don’t apply fertilizers you attain nothing.” (Animal husbandry Officer, Kato Sub County).Lack of moisture in the soil due to drought reduces the absorption of nutrients from the soil by the crops leading to reduced soil fertility.

		Count	Column N %
EFF C.C Soil fertility	No	4	1.0
	Yes	394	99.0

Table 4:20. Effect of climate change on soil fertility

The majority of the respondent indicated that the change in climate has impacted their income (95.0%). Results further show that 89.9% of the respondents indicated that farm income has decreased with change in climatic conditions. And only 5.0% reported increasing farm income due to climatic changes.

Climate change has affected planting as reported by 97.5% of the respondents. Only 2.5% indicated that climate change has not had any effect of planting. Of those who indicated reduction in planting due to climate change, 77.1% the climate has reduced the planting period. This has affected many households since many use simple land preparation methods and use family members to provide labor. In contradiction, information from the key informant revealed that as a result of climate change, the crop growing season has increased since people plant crops whenever it rains as supported by the quotation below;

“According to the way I see and in my observation, it has increased people plant more than 3 times and at any time rain comes” (Chairman local council iii, Lwanjusi Sub County).

Drought stress often results in falling off of flowers, premature drying of crops among other effects. Respondents revealed that climatic changes have resulted in a lot of drought stress to the crops (70.4%) (**Error! Reference source not found.**).

		Count	Column N %
EFF C.C Drought stress	No	118	29.6
	Yes	280	70.4

Table 4:21. Effect of climate change on crops

The major issues associated with drought stress was stunted growth (32.1%) followed by low production (25.7%), yellowing (25.0%) and drying up (17.1%). Results show that drought stress is significantly associated with changes in temperature ($p=0.003$). Increase in temperatures also increases the rate of evaporation of moisture from the soil hence making nutrients and water less available to the plants. This therefore leads to drought stress.

4.4 Adaptation strategies employed by respondents

Adaptation is one of the ways through which the farmers have been able to continue with their activities amidst the change in climate. Results show that 92.7% of the farmers have put forward some adaptation strategies.

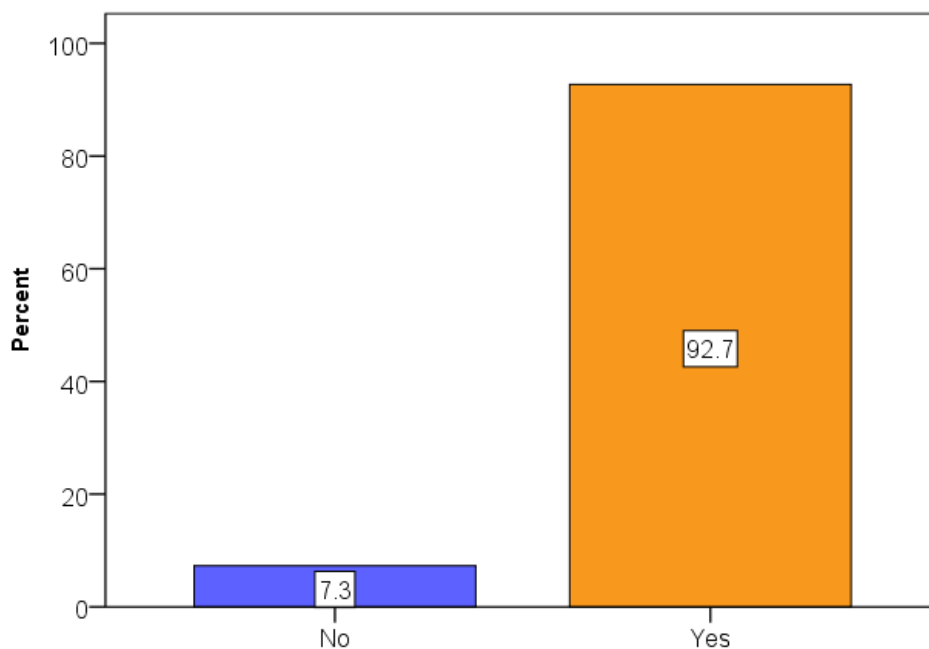


Figure 4:10. Percentage of respondents practicing adaptation strategies

The most common adaptation practices used by the farmers are terracing (24.4%). Terracing has been used by the farmers to control soil erosion especially those on a slightly sloping gradient. Planting of trees was done by farmers in relatively flat areas.

Adaptation Practices	Count	%
Contour ploughing	25	6.8
Diversification	41	11.1
Early planting	28	7.6
improved varieties	31	8.4
Mulching	47	12.7
planting trees	60	16.3
Terracing	90	24.4
Use of fertilizer	47	12.7

Table 4:22. Adaptation strategies practiced by respondents in the study area



Figure 4.11. Contour ploughing and terracing as adaptation strategy used by some of the farmers in the study area



Figure 4.12. A section of farmers land planted with trees as an adaptation strategy

The strategies used to adapt to climate change have varied from one respondent to the other depending on a number of factors (see **Error! Reference source not found.** below).

Pearson Chi-Square Tests

	A	B	C	D	E	F	G	H	I	J	K	L	M
Adapt Chi-Practice square	38.202	3.392	.055	1.748	.015	.413	1.745	.527	22.459	3.763	10.018	2.235	.262

df	4	2	1	1	1	2	4	3	7	3	4	3	1
Sig.	0.000*	0.183	0.814	0.186	0.0902	0.813	0.782	0.913	0.002*	0.288	0.040*	0.525	0.609

*. The Chi-square statistic is significant at the .05 level.

A= Land Preparation; B= Land ownership; C= Time spent Farming; D= Time spent Area; E= Have Personal Savings; F=Occupation; G= HH Size; H= Education; I= Tribe; J= Marital status; K= Religion; L= Age; M= Sex

Table 4:23. Relationship between adaptation to climate change and demographic factors

Findings show that there are very many adaptation strategies by the respondents. However, the most commonly used adaptation strategy is working in groups (43.1%). These groups help in getting the weeding done quickly and in the shortest time, harvesting in time, and even opening up of new fields. Implementation of activities and projects often faces many challenges. The results reveal that the cost of inputs especially agriculture inputs is high (see **Error! Reference source not found.** below). Inputs like fertilizers and pesticides are very expensive yet they would help in boosting the potential of the soil to provide the required nutrients to the plants as well as controlling the climate induced weeds and pests.

Adaptation practice	Count	Percentage
Borrowing	4	6.9
Hire land	10	17.2
Learn from fellow farmers	5	8.6
Reduce on the quantity required	7	12.1
Use alternative fertilizers	7	12.1
Work in groups	25	43.1

Table 4:24. Alternative adaptation strategies adopted by respondents.

Challenges faced while implementing adaptation strategies	Count	Column N %
Expensive inputs	161	43.6
Fake inputs	75	20.3
Lack of Extension services	21	5.7

Lack of labour	9	2.5
Lack of material	34	9.2
Limited land	45	12.2
Other reasons	24	6.5

Table 4.25. Challenges faced by farmers during the implementation of adaptation strategies



Figure 4.13. A farmer using family labour to drain water logged garden before planting in Lwanjusi Sub-county.

However, information from FGDs and KIIs also revealed another major reason for non-adoption and response to climate change impacts to be the very high poverty levels among the small holder farmers which make them incapable of accessing the available sound technologies. Information from KIIs also noted land fragmentation and the presence of fake technologies particularly agro inputs which do not help farmers at all and make them succumb to the shocks of the changing climate. The quotation below supports the results that farmers lack capabilities to access improved technologies to cope with the changing climate,

“Most of the mitigation strategies require money. So the biggest challenge here is money to buy fertilizers, money to buy improved seed inputs, so the biggest challenge is low income among the farmers” (Agricultural Officer, Kaato Sub County).

The largest percentage of respondents did not have access to extension services (58.5%)**Error! Reference source not found.** However, those that had access to extension services received guidance on agricultural inputs (44.2%) among others. The inputs include cassava cuttings, coffee seedlings, pesticides and maize seed. Other respondents indicated that they received trainings (44.2%), while the rest received advisory services (11.6%). Advisory service was given on authentic sources/suppliers, the pesticides, herbicides, fertilizers among other inputs.

		Count	Percentage (%)
Access Agric. Ext Services	No	233	58.5
	Yes	165	41.5

Table 4:26. Percentage of respondents who had access to extension services

Religion ($p=0.025$), having personal savings (0.001)**Error! Reference source not found.**, and education level significantly influenced access to extension services by the farmers. Respondents with some level of savings could easily afford to facilitate the agricultural officers with fuel to visit their gardens and at any time. Farmers revealed that with the small weekly savings, they can easily visit the officers in their respective offices.

Pearson Chi-Square Tests

	Time spent Farming	Time spent on Areas	Have Personal Savings	Sex	Age	Religion	Marital status	Tribe	Education	HH Size	Occupation
Chi-square	.125	.653	10.762	.462	5.116	11.122	6.536	20.709	15.439	1.186	3.779
df	1	1	1	1	3	4	3	7	3	4	2
Sig.	.724	.419	.001*	.497	.164	.025*	.088	.004*	.001*	.880	.151

*. The Chi-square statistic is significant at the .05 level.

Table 4:27. Factors influencing access to agricultural extension services

Only a small proportion of the respondents 2.5% owned irrigation water sources. Those who had irrigation water sources owned a stream (70%), close proximity to the river (20%) and the rest owned ponds(see **Error! Reference source not found.**).

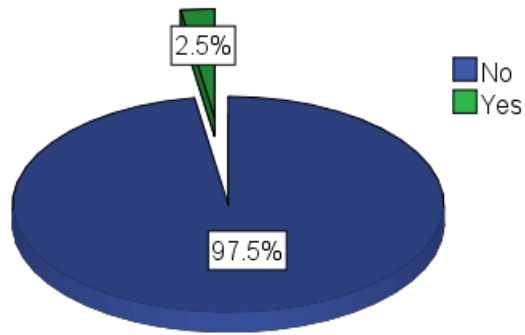


Figure 4:14. Percentage of respondents who own sources of water for irrigation



Figure 4:15. River Nangilima which has always acted as a source for irrigation water

Further, the results show that those who owned irrigation source irrigated their crops weekly (70.0%). Others irrigated daily (20%) while the rest of the percentage did not irrigate their crops despite owning irrigation source.



Figure 2.16. Irrigation of cabbage in Kato sub-county, which has enabled farmers to produce throughout the year

The largest percentage of the respondents did not belong to any farmers group (62.3%). Membership to a farmer group is social capital to help the farmer adapt to the effects therefore lack of membership makes adaptation difficult. Group membership of male and female smallholder farmers could enhance adaptive capacities to climate risks in farming communities. Such group affiliations and relationships promote the transmission of traditional knowledge to shape indigenous adaptation for climate resilience (Dapilah et al., 2020).

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter attempts to provide a summary of the results that were derived from the various analyses in the study. The conclusion is drawn from the results and the discussion in chapter 4 are also presented and finally some recommendations.

5.1 Conclusion

The study was designed to examine the effect of climate change on smallholder farmers' livelihoods in Manafwa District. The district is bordered by Bududa district to the north, Kenya to the east and south, Tororo district to the south-west, and Mbale district to the west (Oyana et al., 2015). The study used various sampling techniques. Manafwa district was selected purposively because it experiences various effects of climate change and majority of the people in the district are small holder farmers engaged in smallholder agriculture as the main economic activity (Batte et al., 2024). Stratified random sampling was used to select the sample sub counties of Kato and Lwanjusi on the basis of high, and low, effect of climate change risk respectively.

The 3 guiding objectives of the study included:-i) To analyze smallholder farmers' perception and understanding of local climate change, ii) To assess the small-holder farmers' livelihood situation amidst climate change in Manafwa District and finally and iii) To evaluate the adaptation strategies undertaken by small-holder farmers in Manafwa District. Simple random sampling was used to select the 3 sample parishes from each of the two Sub-counties. Key informants were selected purposively while systematic random sampling was used to select the sample households. This randomization enhanced data validity and reliability because it reduced the effects of extraneous variables. According to (Batte et al., 2024),Manafwa District has a total of 72815 households therefore a sample of 398 farmers were included in the survey. This was determined statistically using the Slovin's formula (Tejada & Punzalan, 2012).

The study adopted a survey design since the aim of the researcher was to describe and explain the events as they are. This design helped in rapid data collection, it was extensive and it also helped in understanding the study population. The study used a mixed method approach involving

qualitative and quantitative approaches. A mixed method was superior to a single method because it enhanced data quality through triangulation and complementarities. For objective 1 and 2, data was collected using a household survey consisting of semi-structured questionnaires with closed and open-ended questions. The questionnaire was designed and put on phone using Epi-collect 5 program to enable data collection and entry. Objective 3 data was collected using key informant interviews and focus group discussions by asking participants verbally open-ended questions and data was recorded using a recorder and it was also noted down on paper. In order to enhance data validity, the questionnaire was pretested before final use.

With regard to smallholder farmers' perception and understanding of local climate change, results showed that respondents who had been in the area could easily make comparisons of the current and past, and thus were able to confirm that there was a change in temperature and the nature of the change was an increase. This is in line with Studies across Africa, Asia, and Latin America consistently showing that smallholders perceive shifts in rainfall patterns, increasing temperature, and more frequent droughts as the most significant indicators of climate change (FAO, 2021). Rainfall variability is the most commonly reported change, often linked to shorter rainy seasons, delayed onset, or increased unpredictability (World Bank, 2020). Temperature increases are also noted, particularly through farmers' observations of prolonged dry spells and heat stress on crops (Zenda et al., 2024). In some cases, farmers' perceptions do not align fully with meteorological data, but their local knowledge remains a key determinant of adaptive decision-making (IPCC, 2019). Perceptions are influenced by experience, education, access to information, and cultural factors. For instance, households with greater exposure to extension services and climate information are more likely to accurately perceive and act on climate signals (FAO, 2021).

In the aspect of Small-holder farmers' livelihood situation amidst climate change, results showed that occupation of the respondent significantly affected livelihood. It was revealed that whenever there is a change in temperature, farmers' crops like beans were greatly affected by the high temperatures. This is because high temperatures cause a lot of evaporation of moisture from the soil leading to water stress to the crops. In addition, majority of the respondents indicated that the change in climate had affected the market for farm produce. This is because crop diseases are prevalent during excess rainfall hence reducing the quality of the produce which in turn reduces the market price.

In the evaluation of the adaptation strategies undertaken by small-holder farmers, results showed that 92.7% of the farmers have put forward some adaptation strategies. The most common adaptation practice used by the farmers was terracing. Terracing was used by the farmers to control soil erosion especially those on a slightly sloping gradient. Other adaptation strategies employed by the small holder farmers included: - contour ploughing, diversification as a way of adaption helps to increase resilience to abiotic stress, it reduces the risk of crops failing completely (Vernooy et al, 2022), early planting, use of improved varieties, mulching, planting of trees and use of both organic and inorganic fertilizers. This is in line with the adoption of these strategies is shaped by resource access (land, credit, inputs), institutional support (extension, cooperatives), and social networks. Women farmers, despite being central to food production, often face greater barriers to adaptation due to limited control over land and inputs (FAO, 2021). Small holder farmers in Manafwa district experience a number of climate change related disasters majorly; excessive rainfall with flooding, landslides, excessive rainstorms, windstorms during the rainy season and excessive temperatures, severe droughts and sandstorms during the dry season. These pose various effects on small holder farmers in a number of ways including; Destruction of crops causing food insecurity, build-up of diseases, relocations, poor hygiene, and destruction of houses, soil erosion, reduced water availability and fear of floods. Given their low capacity to effectively respond to these effects, small holder farmers usually adopt using the above mentioned strategies. The literature shows that perceptions and adaptation are closely linked: farmers' ability to recognize climate signals shapes their adaptation choices, while structural barriers determine the extent and effectiveness of those choices. Enhancing adaptive capacity requires strengthening access to climate information, credit, and extension services, alongside promoting inclusive policies that address gender and social inequities. Future research should focus on integrating local perceptions with scientific climate data and evaluating the long-term sustainability of adaptation practices.

5.2 Recommendations

Even when majority of the respondents had some knowledge about climate change, much effort is required to ensure that the whole community becomes aware of climate change since climate change effects have no boundary. Sensitizations should target the key interventions that can be employed to improve resilience of farming systems particularly in disaster prone areas which may among others include; mulching, use of organic manure, terracing on steep slopes, cover cropping

and other land based drought management practices. This should be done using community sensitizations through; local leaders, radios, televisions, group trainings among others.

Since the results showed that majority of the respondents experience the effects of climate change, it depicts significant impacts on the household welfare. This calls for adoption of climate change safety system that comprises of several initiatives to reduce risk in a holistic manner. The key components of the system are; comprehensive enforcement of environmental standards, community participation for climate safety, systems for early warning and emergency response, and comprehensive databases of climate hazard events and implemented disaster risk mitigation measures.

Since results reflected destruction of food crops as the major effect posed by climate change, there is need to design interventions that beef up food security, increase land ownership, increase livestock production coupled with education and women empowerment to be harnessed. This will help to enhance build-back better, resilience and capacity of the households.

In order to increase adoption of the climate change mitigation and adaptation measures, there is urgent need to promote Community-based disaster risk management that involves the potentially affected communities at the local level. This includes community assessments of hazards, vulnerabilities and capacities, and their involvement in planning, implementation, monitoring and evaluation of local action for risk reduction.

More efficient, user-friendly and at the same time affordable climate change adaptation and mitigation interventions need to be designed and availed to the small holder farmers. Accordingly, the capacity of the small holder farmers need to be enhanced to increase access and affordability of the available efficient climate change adaptation and mitigation technologies through creation of alternative employment opportunities for the communities for better household income gains.

References

- Abid, M., Scheffran, J., Schneider, U. A., & Elahi, E. (2019). Farmer perceptions of climate change, observed trends and adaptation of agriculture in Pakistan. *Environmental Management*, *63*, 110–123.
- Alston, J. M., & Pardey, P. G. (2014). Agriculture in the global economy. *Journal of Economic Perspectives*, *28*(1), 121–146.
- Altieri, M. A., Funes-Monzote, F. R., & Petersen, P. (2012). Agroecologically efficient agricultural systems for smallholder farmers: Contributions to food sovereignty. *Agronomy for Sustainable Development*, *32*(1), 1–13. <https://doi.org/10.1007/s13593-011-0065-6>

- Altieri, M. A., & Nicholls, C. I. (2017). The adaptation and mitigation potential of traditional agriculture in a changing climate. *Climatic Change*, *140*, 33–45.
- Antwi-Aggyei et al. (2014). *Livelihood adaptations to climate variability: insights from farming households in Ghana*.
- Anwar, F., Mohsin, M., & Arshad, S. (2023). A Statistical Survey on the Socioeconomic and Demographic Livelihood of Brick Kiln Workers: A Case Study of Bahawalpur District, Punjab, Pakistan. *Proceedings of the Pakistan Academy of Sciences: A. Physical and Computational Sciences*, *60*(4), 55–67.
- Anwar, M. R., Liu, D. L., Macadam, I., & Kelly, G. (2013). Adapting agriculture to climate change: a review. *Theoretical and Applied Climatology*, *113*, 225–245.
- Arbuckle Jr, J. G., Morton, L. W., & Hobbs, J. (2015). Understanding farmer perspectives on climate change adaptation and mitigation: The roles of trust in sources of climate information, climate change beliefs, and perceived risk. *Environment and Behavior*, *47*(2), 205–234.
- Baffour-Ata, F., Awugyi, M., Ofori, N. S., Hayfron, E. N., Amekudzi, C. E., Ghansah, A., & Akorli, R. (2023). Determinants of yam farmers' adaptation practices to climate variability in the Ejura Sekyedumase municipality, Ghana. *Heliyon*, *9*(3).
- Bamutaze, Y., Thiemann, S., & Förch, G. G. (2014). Integrated Watershed Management for Urban Water Security Integrated Watershed Management-a Tool for Urban Water Security Workshop Results from Mbale, Uganda. *Proceedings of the Integrated Watershed Management for Urban Water Security Integrated Watershed Management-a Tool for Urban Water Security Workshop Results from Mbale, Mbale, Uganda*, 10–16.
- Basher, R. (2006). Global early warning systems for natural hazards: systematic and people-centred. *Philosophical Transactions of the Royal Society a: Mathematical, Physical and Engineering Sciences*, *364*(1845), 2167–2182.
- Batte, C., Nuwasiima, S., Semulimi, A. W., Apio, P. O., Mutebi, R. K., Mwesigwa, M. M.,

- Twinamasiko, N., Siddharthan, T., Mukisa, J., & Mukunya, D. (2024). Coping strategies of school-going adolescents during the COVID-19 pandemic in the climate vulnerable Manafwa watershed, Uganda. *BMC Psychology*, *12*(1), 312.
- Belay, A., Oludhe, C., Mirzabaev, A., Recha, J. W., Berhane, Z., Osano, P. M., Demissie, T., Olaka, L. A., & Solomon, D. (2022). Knowledge of climate change and adaptation by smallholder farmers: evidence from southern Ethiopia. *Heliyon*, *8*(12).
- Below, T. B., Schmid, J. C., & Sieber, S. (2015). Farmers' knowledge and perception of climatic risks and options for climate change adaptation: a case study from two Tanzanian villages. *Regional Environmental Change*, *15*, 1169–1180.
- Bhatta, G. D., & Aggarwal, P. K. (2016). Coping with weather adversity and adaptation to climatic variability: a cross-country study of smallholder farmers in South Asia. *Climate and Development*, *8*(2), 145–157.
- Brown, O., Hammill, A., & McLeman, R. (2007). Climate change as the 'new' security threat: implications for Africa. *International Affairs*, *83*(6), 1141–1154.
- Bryan, E., Deressa, T. T., Gbetibouo, G. A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science & Policy*, *12*(4), 413–426.
- Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2013). Adapting agriculture to climate change in Kenya: Household strategies and determinants. *Journal of Environmental Management*, *114*, 26–35.
- Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., & Lobell, D. B. (2009). Warming increases the risk of civil war in Africa. *Proceedings of the National Academy of Sciences*, *106*(49), 20670–20674.

- Chambers & Conway. (1992). *An Analysis of the Effectiveness Farmer Field School (FFS) Approach in Sustainable Rural Livelihood (SRL): The Experience of Punjab-Pakistan*. Agricultural Sciences, Vol.6.
- Chikaire, J., & Nnadi, F. N. (2011). Indigenous Knowledge for Climate Change Mitigation and Adaptation in Agriculture in sub-Saharan Africa. *Report and Opinion*, 3(5), 32–40.
- Connolly-Boutin, L., & Smit, B. (2016). Climate change, food security, and livelihoods in sub-Saharan Africa. *Regional Environmental Change*, 16, 385–399.
- Cooper, P. J. M., Dimes, J., Rao, K. P. C., Shapiro, B., Shiferaw, B., & Twomlow, S. (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Agriculture, Ecosystems & Environment*, 126(1–2), 24–35.
- Egeru, A., Barasa, B., Nampijja, J., Siya, A., Makooma, M. T., & Majaliwa, M. G. J. (2019). Past, present and future climate trends under varied representative concentration pathways for a sub-humid region in Uganda. *Climate*, 7(3), 35.
- F Dapilah, J Ostergaard Nielsen, Cecillie Friis, (2020). The role of social networks in building adaptive capacity and resilience to climate change. A case study from Northern Ghana.
- Fan, L., Lu, C., Yang, B., & Chen, Z. (2012). Long-term trends of precipitation in the North China Plain. *Journal of Geographical Sciences*, 22, 989–1001.
- Fonta, W., Edame, G., Anam, B. E., & Duru, E. J. C. (2011). *Climate change, food security and agricultural productivity in Africa: Issues and policy directions*.
- Fox, K. M., Nelson, S., Frankenberger, T. R., & Langworthy, M. (2018). Climate change adaptation in Ethiopia: developing a method to assess program options. In *Resilience* (pp. 253–265). Elsevier.
- Getachew, F., Bayabil, H. K., Hoogenboom, G., Teshome, F. T., & Zewdu, E. (2021). Irrigation and shifting planting date as climate change adaptation strategies for sorghum. *Agricultural*

Water Management, 255, 106988.

- Gornall, J., Betts, R., Burke, E., Clark, R., Camp, J., Willett, K., & Wiltshire, A. (2010). Implications of climate change for agricultural productivity in the early twenty-first century. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), 2973–2989.
- Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., Rajaofara, H., & MacKinnon, J. L. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369(1639), 20130089.
- Hisali, E., Birungi, P., & Buyinza, F. (2011). Adaptation to climate change in Uganda: evidence from micro level data. *Global Environmental Change*, 21(4), 1245–1261.
- IPCC. (2021). *AR6 Climate Change: The physical Science Basis*.
- IPCC. (2014). *Impacts, adaptation, and vulnerability*.
- Khatri, B. B., & Pasa, R. B. (2023). People's perception on climate change: The context of local and global discourse. *Asian Journal of Population Sciences*, 68–79.
- Kitoyi, A. (2023). *Factors affecting the adoption of improved ground nuts varieties by the farmers of Khabutoola sub county Manafwa district*.
- Mcguigan, C., Reynolds, R., & Wiedmer, D. (2002). London School of Economics Consultancy Project for The Overseas Development Institute POVERTY AND CLIMATE CHANGE: ASSESSING IMPACTS IN DEVELOPING COUNTRIES AND THE INITIATIVES OF THE INTERNATIONAL COMMUNITY. *London School of Economics Consultancy Project for the Overseas Development Institute*, 1–40.
- Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management*, 43, 804–816.

- Mhlanga, M. L. (2004). Adaptation to climate change: Technology needs in Lesotho. *Energy and Land Use Change and Forestry, Lesotho Meteorological Services, Ministry of Natural Resources, Maseru, Lesotho.*
- Minai, J. O. (2015). *Assessing the spatial variability of soils in Uganda.* Purdue University.
- Monarchi, D. E., & Puhr, G. I. (1992). A research typology for object-oriented analysis and design. *Communications of the ACM, 35(9), 35–47.*
- Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences, 104(50), 19680–19685.*
- Mugagga, F., Kakembo, V., & Buyinza, M. (2012). Land use changes on the slopes of Mount Elgon and the implications for the occurrence of landslides. *Catena, 90, 39–46.*
- Mutekwa, V. T. (2009). Climate change impacts and adaptation in the agricultural sector: The case of smallholder farmers in Zimbabwe. *Journal of Sustainable Development in Africa, 11(2), 237–256.*
- Mutua, K., & Goda, P. (2021). Multidimensional assessment of European agricultural sector adaptation to climate change. *Studies in Agricultural Economics, 123(1), 8–22.*
- Namugaya, J. (2017). Current Causes of Girls' Low Performance in Physical Sciences from Hard-to-reach Secondary Schools in Eastern Uganda. *International Journal of Secondary Education, 5(1), 12.* <https://doi.org/10.11648/j.ijsedu.20170501.12>
- Nath, P. K., & Behera, B. (2011). A critical review of impact of and adaptation to climate change in developed and developing economies. *Environment, Development and Sustainability, 13(1), 141–162.* <https://doi.org/10.1007/s10668-010-9253-9>
- NEMA. (2020). *Annual National Lead Agency Report.*
- Niang et.al. (2014). *Evaluation of onset and Cessation of Rainfall and Temperature on Maize in Akure, Ondo State, Nigeria.*

- Nyong, A., Adesina, F., & Osman Elasha, B. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and Adaptation Strategies for Global Change*, 12, 787–797.
- Okau, P. (2023). *Assessment of Flood Susceptibility in Mount Elgon Region of Uganda Under a Changing Climate and Risk Implication to Farmland Food Security*. University of Nairobi.
- Okoth, J. M., Otim, D., & Kamalha, E. (2024). Distribution of Floods Frequency of Manafwa River, Uganda. *East African Journal of Engineering*, 7(1), 1–20. <https://doi.org/10.37284/eaje.7.1.1670>
- Olmos, S. (2001). *Vulnerability and adaptation to climate change: concepts, issues, assessment methods*. Climate Change Knowledge Network (CCKN).
- Ongoma & Awange. (2019). Evaluation of precipitation simulations in CMIP6 models over Uganda. *International Journal of Climatology* .
- OPM. (2015). *Annual report*.
- Oyana, T. J., Kayendeke, E., Bamutaze, Y., & Kisanga, D. (2015). A field assessment of land use systems and soil properties at varied landscape positions in a fragile ecosystem of Mount Elgon, Uganda. *African Geographical Review*, 34(1), 83–103. <https://doi.org/10.1080/19376812.2014.929970>
- Pender, J., Nkonya, E., Jagger, P., Sserunkuuma, D., & Ssali, H. (2004). Strategies to increase agricultural productivity and reduce land degradation: evidence from Uganda. *Agricultural Economics*, 31(2-3), 181–195.
- Ricart, S., Castelletti, A., & Gandolfi, C. (2022). On farmers' perceptions of climate change and its nexus with climate data and adaptive capacity. A comprehensive review. *Environmental Research Letters*, 17(8), 83002.
- Ríos-González, A., Jansen, K., & Sánchez-Pérez, H. J. (2013). Pesticide risk perceptions and the differences between farmers and extensionists: Towards a knowledge-in-context model.

Environmental Research, 124, 43–53.

Sakho-Jimbira, S., & Hathie, I. (2020). The future of agriculture in Sub-Saharan Africa. *Policy Brief*, 2(3), 18.

Saunders, M. N. K., & Townsend, K. (2018). Choosing participants. *The Sage Handbook of Qualitative Business and Management Research Methods*, 480–494.

Sebuliba, E., Majaliwa, J. G. M., Isubikalu, P., Turyahabwe, N., Eilu, G., & Ekwamu, A. (2021). Characteristics of shade trees used under Arabica coffee agroforestry systems in Mount Elgon Region, Eastern Uganda. *Agroforestry Systems*, 1–13.

Sebuliba, E., Mwanjalolo, M., Turyahabwe, N., Eilu, G., & Ekwamu, A. (2022). Effect of Inorganic Fertilizer Application on Green House Gas Emissions and Microbial Activity under Coffee Agroforestry in Eastern Uganda. *African Journal of Rural Development*, 7(3), 275–296. <https://doi.org/10.1002/essoar.10512959.1>

Scoones. (2015). The politics of Sustainability and development.

Shepherd, B. (2016). *Uganda*.

Smit & Wandel. (2006). Adaptation, adaptive capacity and vulnerability. 282-292.

Singh, S. (2020). Farmers' perception of climate change and adaptation decisions: A micro-level evidence from Bundelkhand Region, India. *Ecological Indicators*, 116, 106475.

Slater, R., Peskett, L., Ludi, E., & Brown, D. (2007). Climate change, agricultural policy and poverty reduction—how much do we know. *Natural Resource Perspectives*, 109(7), 1–6.

Soubry, B., Sherren, K., & Thornton, T. F. (2020). Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007–2018. *Journal of Rural Studies*, 74, 210–222.

Tejada, J. J., & Punzalan, J. R. B. (2012). On the misuse of Slovin's formula. *The Philippine*

Statistician, 61(1), 129–136.

Thomas, K., Hardy, R. D., Lazrus, H., Mendez, M., Orlove, B., Rivera-Collazo, I., Roberts, J. T., Rockman, M., Warner, B. P., & Winthrop, R. (2019). Explaining differential vulnerability to climate change: A social science review. *Wiley Interdisciplinary Reviews: Climate Change*, 10(2), e565.

Thornton, P. K., Ericksen, P. J., Herrero, M., & Challinor, A. J. (2014). Climate variability and vulnerability to climate change: A review. *Global Change Biology*, 20(11), 3313–3328. <https://doi.org/10.1111/gcb.12581>

Thornton, P. K., & Herrero, M. (2014). Climate change adaptation in mixed crop–livestock systems in developing countries. *Global Food Security*, 3(2), 99–107.

Twongyirwe et al. (2019). Perceived effects of drought on security in South-Western Uganda: Coping responses and determinants.

TO, E.-B. A., & EBA, C. C. A. (2010). *National Guidelines*.

Wolf, J., & Moser, S. C. (2011). Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change*, 2(4), 547–569.

APPENDICES

APPENDIX I: INTERVIEW SCHEDULE FOR KEY INFORMANTS

Introduction

My name is Olupot Justin. I am a Masters Student in the University of Busitema university carrying out my research entitled: Effect of Climate Change on small-holder farmers’ livelihoods in Manafwa District, Uganda: We request you to participate in this survey and assure you that the information obtained will be used solely for purposes of this research, and that your identity as well as responses will be treated with confidentiality. In responding to the questions, there is no right or wrong answer, we are only interested in your honest opinion. The research findings will help to improve interventions on the effects of climate change on smallholder farmers’ livelihoods in this area.

General Information

Name of Respondent: (Optional)

Designation:.....

District:.....

Sub-county:.....

Parish:.....

Have you noticed climatic change in Manafwa district over time?

Probe with;

Give some examples of climatic changes have you noticed?

What do you think are the causes of climate change in this area?

Probe with;

Deforestation

Encroachment on wetlands

Development

Industrialization

Others (specify)

What are some of the seasonal weather changes in this area?

Probe with;

Changes in temperature

Changes in precipitation

Changes in length of the crop growing season

Changes in flood occurrence and severity

Changes in landslide occurrence and severity

Changes in windstorms severities

Changes in sandstorms severities

Changes in drought intensities and occurrences

In your opinion, how have the changes in climate affected small holder farmers in Manafwa District?

Probe with;

Pest incidences

Disease incidences

Crop quality

Soil fertility

Crop productivity

Crop markets

Cropping seasons

Prices of crop products

What are the mitigation and adaptation strategies adopted by the small holder farmers to address the adverse impacts of climate change?

Probe with;

Practices and technologies being used by farmers (Irrigation, good agronomic practices etc)

Access to agricultural extension services

Membership in farmer groups (Joint marketing, savings, value addition etc)

6. What are some of the challenges being faced by the farmers in trying to combat climate change effects?

7. What are some of the policy recommendations that the government can adopt in order to address the adverse impacts of climate change?

**APPENDIX 2: GUIDING QUESTIONS FOR FOCUS GROUP DISCUSSIONS WITH
SELECTED FARMERS.**

Introduction

My name is Olupot Justin. I am a Masters Student in the University of Busitema university carrying out my research entitled: Effect of Climate Change on small-holder farmers’ livelihoods in Manafwa District, Uganda: We request you to participate in this survey and assure you that the information obtained will be used solely for purposes of this research, and that your identity as well as responses will be treated with confidentiality. In responding to the questions, there is no right or wrong answer, we are only interested in your honest opinion. The research findings will help to improve interventions on the effects of climate change on small holder farmers’ livelihoods in this area.

General Information

District :

Sub-county :

Parish :

Village :

Focus group size:

ID	Name of respondent	Age	Sex	Highest education level	House hold size	Marital status	Years spent in farming

Have you noticed climatic change in Manafwa district over time?

Probe with;

Give some examples of climatic changes have you noticed?

What do you think are the causes of climate change in this area?

Probe with;

Deforestation

Encroachment on wetlands

Development

Industrialization

Others (specify)

What are some of the seasonal weather changes you have noticed in this area?

Probe with;

Changes in temperature

Changes in precipitation

Changes in length of the crop growing season

Changes in flood occurrence and severity

Changes in landslide occurrence and severity

Changes in windstorms severities

Changes in sandstorms severities

Changes in drought intensities and occurrences

In your opinion, how have the changes in climate affected small holder farmers in Manafwa District?

Probe with;

Pest incidences

Disease incidences

Crop quality

Soil fertility

Crop productivity

Crop markets

Cropping seasons

Prices of crop products

What mitigation and adaptation strategies have you adapted to address the adverse impacts of climate change?

Probe with;

Practices and technologies being used by farmers (Irrigation, good agronomic practices etc)

Access to agricultural extension services

Membership in farmer groups (Joint marketing, savings, value addition etc)

5. What challenges do you face in trying to combat climate change effects?

