CLIMATE CHANGE IMPACTS ON SMALLHOLDER COTTON FARMING: RISKS, VUNERABILITY, AND ADAPTATION IN KITGUM DISTRICT, UGANDA

BY

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23/U/0620/MAG/PS

A DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF ARTS IN GEOGRAPHY DEGREE OF GULU UNIVERSITY

AUGUST 2026

DECLARATION

I, Aneno Irene Apwoyochan, hereby declare that this research dissertation, entitled ***"Climate Change Impacts on Smallholder Cotton Farming: Risks, vulnerability, and Adaptation in Kitgum District, Uganda,"*** is my creative effort, and it has not been submitted to any institution of learning for any academic award.

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APPROVAL

This is to certify that the dissertation titled ***"Climate Change Impacts on Smallholder Cotton Farming: Risks, vulnerability, and Adaptation in Kitgum District, Uganda"*** has been completed under our supervision and is approved for submission to the Directorate of Research and Graduate Training.

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DEDICATION

I dedicate this piece of work to my grandmother, Gertrude Lukwiya (Mrs.), for building a strong educational foundation.

“May the Almighty God bless you, mama.”

ACKNOWLEDGEMENT

I would like to convey my utmost and sincere indebtedness to the Almighty God for empowering me to complete my dissertation with delight. “All glory to God for how far he has brought me with the work”.

I acknowledge with gratitude the brainchild behind Vulnerability and Climate Change Adaptation in Conflict-Affected Regions (VUCCA – Project) and the whole VUCCA- project team of Gulu University, for the financial support rendered towards this research, without which this work would not have reached this far.

I acknowledge with gratitude my supervisors, Dr. Expedito Nuwategeka and Dr. Kilama Justine Luwa. Your scholarly thoughts, academic support, constructive guidance, and encouragement during all stages of this study. Without you, this research wouldn’t have been successful; May the Almighty God bless you all.

In particular, acknowledgment goes to lecturers in the department of Geography, namely Dr. George Oriangi, Dr. Chombo Okecho, Prof Wilfred Lajul, Mr Patrick Okot, Mr. Yeeko Kasira, and the entire Geography department at Gulu University. May the good Lord bless you abundantly!

I also thank so much my family especially my husband and children not forgetting my sisters for giving the support and time I needed during the study and this work.

Last but not least, I further extend my appreciation to my study respondents whose cooperation made it possible for me to collect the required data, especially the field guides, most distinguished one, Johnson Omony. All my friends, especially Mr. and Mrs. Jennifer Okello and Frank Okello, and those whose names can’t be mentioned because the list is long, thank you for your emotional support and encouragement.

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ABSTRACT

Climate change presents a significant global problem that greatly affects agriculture, especially in developing countries impacting small-scale farmers. This study focused on assessing the impact of climate change on smallholder cotton farmers' risks, adaptation strategies, and vulnerability in Kitgum District, Northern Uganda. The study was conducted using a descriptive case study design involving qualitative and quantitative research approaches targeting 291 respondents including smallholder cotton farmers, government officials and Non-Governmental Organization. The study analyzed 188 fully filled household semi-structured questionnaires using SPSS, Pearson correlation coefficient and thematic analysis and (i) determined the perception of farmers to climate change risk, (ii) assessed coping mechanisms and (iii) identified factors that influence their vulnerability. Content analysis was used to analyze data of 7 key informant and 1 focus group discussion. The results indicate that farmers perceive erratic rainfall (70%) and increased temperatures (65%), as significant climate change risks. To adapt, they employ strategies such as crop diversification (60%) and using drought-resistant varieties (50%). Factors influencing vulnerability majorly include limited access to financial resources (75%), lack of climate information (68%). However, the challenges faced by farmers show weaker but still significant correlations with both community impacts ($r=.240$, $p<.01$) and adaptation hindrances ($r=.226$, $p<.01$), indicating that perceived problems align with actual climate vulnerabilities. In conclusion, smallholder cotton farmers are acutely aware of changing weather patterns, notably rainfall unpredictability, which they perceive regularly. Additionally, climate change is no longer a myth but a reality being experienced by smallholder farmers impacting on their farming activities and livelihood. My study recommends adoption of integrated approaches that advance access to both drought-resistant seed, financial resources and irrigation farming to ensure sustainable agricultural practices to strengthen resilience against climate change impacts.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This section sets the stage for the research. It outlined the main issues that were explored, the objectives of the study, the specific questions it sought to address, and the scope of the research. Additionally, it offered a summary of the key concepts and theoretical foundations used to examine how the situation of small-scale cotton farmers in the Kitgum District of Northern Uganda is affected by climate change, including their susceptibility, potential dangers, and methods for adjusting to these changes.

1.1 Background to the Study

Agriculture is the backbone of survival for billions globally, especially for small-scale farmers who are particularly at risk (Dhillon & Moncur, 2023). More than 70% of people depend on rain fed agriculture especially small holder farmers (FAO, 2018). The world's smallholder farmers produce around a third of the world's food (FAO, 2010). More than 90% of the 570 million farms in the world are run by an individual or a family and depend mainly on family labor. The vast majority of farms in the world are small or very small. Farms of less than two acres account for 84% of the total but control only 12% of all agricultural land (UNDP, 2017). Lowder (2016) further confirms that, smallholder farmers represent over 75% of the world's farms, comprises 60% of the agricultural workforce worldwide and provide over 80% of the food consumed in the developing world (UNEP, 2013). Despite the importance of smallholder farmers to the agricultural sector across the world, smallholder farmers are among the most vulnerable groups. They often struggle with issues like small land sizes, unstable market prices for their goods, and competition from large, industrialized farms as emphasized by (Dhillon & Moncur, 2023). Climate change makes these problems even worse, bringing droughts, floods, and extreme temperatures that threaten food and water supplies, energy access, and the ability of rural communities to make a living (Center, 2021). These effects disproportionately harm already disadvantaged rural populations, especially in developing countries that rely on small-scale farming (Frank & Buckley, 2012). Climate change hinders progress towards achieving the global Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 13 (Climate Action), and worsens poverty (SDG 1) and food insecurity (Godoy et al., 2014).

In Africa, where agriculture is vital for economic growth and food security providing livelihood for over 60% of population (FAO, 2023), climate change poses a major threat, especially to small scale farmers who depend on rainfall and natural ecosystems (Godoy et al., 2014). With limited ability to adapt and access resources, these farmers are highly vulnerable to climate-related disasters such as changing rainfall patterns, pest infestations, and extreme weather (Dhillon & Moncur, 2023). The Intergovernmental Panel on Climate Change (IPCC) emphasizes the need to assess vulnerability by considering exposure, sensitivity, and the capacity to adapt within these farming systems.

Uganda is a prime example of a country where agriculture, especially rain-dependent farming, is crucial to both the economy and the livelihoods of people in rural areas (Barasa, 2019). According to FAO (2018) in the NAP-Ag programme, Agriculture is a crucial sector accounting for approximately 21.9% of its GDP, 85% of its export earnings and above 70% of Ugandans depend on Agriculture. Climate change impacts on the Agricultural sector alone leaves over 70% of the Ugandans population vulnerable and in danger of livelihood insecurity (FAO, 2018). Cotton farming, introduced during colonial times, tracing to the early 20th century remains a key part of Uganda's agricultural sector, providing income for many smallholder farmers, especially in Northern and Eastern Uganda where its majorly grown (Bamwesigye et al., 2020).

Kitgum District is one such area in northern Uganda where cotton has historically supported rural livelihoods. Cotton cultivation began to expand in the 1920s as smallholder farmers were incorporated into the cotton economy. This expansion was part of broader colonial efforts to integrate local agriculture into global markets However, political instability, fluctuating global cotton prices, and pest problems have created significant challenges for cotton farming (Chell, 2013). The growing impacts of climate change, such as unpredictable rainfall and severe weather events, have worsened the challenges faced by smallholder cotton farmers in Northern Uganda especially Kitgum district (Bamanyaki & Aogon, 2020). Research also shows that extreme weather events are becoming more frequent and severe, further endangering smallholder farmers' worldwide (FAO, 2018). These climate-related pressures have led to lower agricultural output and increased vulnerability for farmers in Kitgum District, where reliance on rain-fed farming intensifies the risks.

Although farmers' general vulnerability to climate change is now well known at a global, National and regional scale, great uncertainty remains at specific locations such as Kitgum

district. This poses challenges to policy makers when it comes to undertaking adaptation to climate change. Besides, variation in the vulnerability of similar systems or sectors across different regions is expected as a consequence of regional differences in local environmental conditions and pre-existing stresses to ecosystems (Chombo et al, 2018) as well as the differences in the socio-economic states of the exposed communities. Therefore, limited knowledge exists on the individual level of exposure, vulnerability and adaptation strategies of small holder cotton farmers. Given the importance of the global cotton industry, particularly in sub-Saharan Africa, building the resilience of cotton farmers to climate change has significant implications for global trade, poverty reduction, and food security (Connolly-Boutin & Smit, 2016).

1.2 Problem Statement

Climate change presents a significant global problem that greatly affects agriculture, especially in developing countries impacting small-scale farmers who often lack resources and the ability to adapt (Sridharan, 2019). In Africa, agriculture is a critical sector, providing livelihoods for over 60% of the population and contributing significantly to the continent's GDP (FAO, 2021; FAO., 2023). Smallholder farmers, who make up the majority of agricultural producers in Africa, are particularly vulnerable to climate change due to their dependence on rain-fed agriculture, limited access to resources, and low adaptive capacity(Chombo et al., 2018).

In Uganda, agriculture is the backbone of the economy, with cotton being a critical cash crop for many smallholder farmers . Cotton has been a major export, rasnked third after coffee and tea, making up 15% of the country’s agricultural exports. However, there is a decline due to the possibility of climate change’s impact on the smallholder cotton farmers (Jassogne et al., 2012). Most cotton farming in Uganda takes place in the northern and eastern regions, where smallholder farmers rely on rainfall and have limited access to essential resources, such as fertilizers and pesticides (Yiridomoh et al., 2024) . However, climate change is increasingly threatening the sustainability of cotton farming in these areas. Rising temperatures, unpredictable rainfall, and more frequent extreme weather events are causing lower crop yields, increased pest problems, and greater water scarcity (Oriangi et al., 2024).

Kitgum district is a prime example of a district in northern Uganda where cotton farming plays a crucial role in the livelihood of the rural community (Onek, 2016). However, these climate-driven challenges have made small-scale cotton farmers, particularly in Kitgum

District, more vulnerable. Farmers in this area face additional difficulties, including limited financial resources, a lack of modern farming techniques, and insufficient access to agricultural support services. Furthermore, socio-economic issues such as poverty, low education levels (UBOS, 2024), and limited access to climate-related information further restrict their ability to adapt (Sridharan, 2019).

While considerable research has been conducted on the impact of climate change on agriculture, there has been a lack of detailed, local-level analysis of the specific climate change risks, vulnerabilities and adaptation of smallholder cotton farmers particularly in Kitgum District. This study aimed to address this gap by examining the climate change risks, vulnerability and adaptation strategies of these farmers in three sub-counties of Kitgum District.

1.3 General Objective

The purpose of the study was to assess smallholder cotton farmers' risks, adaptation, and vulnerability to climate change in Kitgum district, Northern Uganda.

1.3.1 Specific Objectives

1. To assess smallholder cotton farmers' perceived climate change risks in Kitgum District.
2. To assess the factors influencing the vulnerability of smallholder cotton farmers to climate change in Kitgum District
3. To assess the adaptation strategies used by smallholder cotton farmers in Kitgum District to adopt to the impacts of climate change.

1.4 Research Questions

1. What are the perceived climate change risks of smallholder cotton farmers in the selected sub-counties of Kitgum District?
2. What are the factors influencing the vulnerability of smallholder cotton farmers to climate change in Kitgum District?
3. What are the adaptation strategies used by smallholder cotton farmers in Kitgum District to adopt to the effects of climate change?

1.5 Significance of the Study

This study was important because it addressed the growing problems caused by climate change impacts for small-scale cotton farmers, who depend on this crop for their survival in the Kitgum District.

The research will provide crucial information about the challenges these farmers face and how well they can adapt. By studying successful adaptation strategies, the social and economic factors that make them vulnerable, the study can inform policy decisions and encourage sustainable agricultural progress. The study will provide evidence that can help government, policy makers and the smallholder farmers to develop policies that can strengthen and improve adaptation to climate change.

1.6 Justification of the Study

Climate change is seriously harming agricultural output worldwide, with regions like Northern Uganda that are already vulnerable being especially hard hit. Cotton farmers in the Kitgum District rely on rainfall for their crops, which makes them very sensitive to the damaging effects of unpredictable weather and extreme climate events. However, there is not much research that specifically examines cotton farming in this area. This study aimed to fill this need by evaluating the vulnerabilities and adaptation methods of small-scale cotton farmers. It will provide important information for those involved creating specific solutions and boosting the farmers' ability to withstand climate change, reduce vulnerability and climate related risks.

Furthermore, it supports Uganda's national goals (Goal 3) for climate resilience and global commitments to the Sustainable Development Goals, especially SDG 1 (No Poverty) because the study identified factors that make smallholder cotton farmers vulnerable to climate change, SDG 2 (Zero Hunger) by examining the impacts of climate change on cotton farming, the study contributes to promoting sustainable agriculture, reducing vulnerability to climate change impacts and strengthening food security and SDG 13 (Climate Action) by providing evidence on climate related risks and support the development of adaptation measures that enhance resilience to climate change.

1.7 Scope of the Study

1.7.1 Geographical scope

The study was conducted in Kitgum District, located in the Northern Region of Uganda, within the Acholi sub-region. The district is characterized by a rural setting with agriculture being the main economic activity (Onek, 2016). Cotton farming in particular, is a significant agricultural practice among smallholder farmers in this district (Kitgum District Local Government, 2021; Uganda Bureau of Statistics, 2024).

Specifically, the study focused on the following sub-counties in Kitgum District, due to their prominence in cotton farming and their varying exposure to climate change risks:

(i) Omiya Anyima: Known for its extensive cotton farming activities, Omiya Anyima provides a representative sample of smallholder cotton farmers in Kitgum District. This sub-county's agricultural practices and socio-economic conditions are critical for understanding the broader impacts of climate change risks on cotton farming.

(ii) Lagoro: Lagoro sub-county, with its unique rainfall pattern and farming practices, adds to the comprehensive understanding of how different districts within Kitgum District are affected by climate change impacts. The farmers here are representative of the district's adaptation strategies.

(iii) Kitgum Matidi: This sub-county is another vital area for cotton cultivation. The diversity in topography and climate-related challenges faced by farmers here make it an important area for studying vulnerability to climate change.

Generally, the geographical scope encompassed among other factors, the varying weather conditions across these sub-counties, including rainfall patterns, temperature fluctuations, and extreme weather events. It also focused on the assessment of factors influencing vulnerability of smallholder cotton farmers including socio-economic factors, such as access to resources, economic stability, and adaptation strategies (Onek, 2016).

1.7.2 Content scope

The study focused on the assessment of small holder cotton farmer’s risk, vulnerability and adaptation to climate change impacts on smallholder cotton farmers in selected sub-counties of Kitgum District. Specifically, the content of the study was limited to three objectives; (i)

To assess smallholder cotton farmers' perceived climate change related risks in selected sub-counties of Kitgum District, (ii) To assess the factors influencing vulnerability of smallholder cotton farmers to climate change in selected sub-counties of Kitgum District, and (iii) To assess the adaptation strategies of smallholder cotton farmers' vulnerability to climate change in selected sub - counties of Kitgum District.

1.7.3 Time scope

The time scope was between 2010 and 2024. This provided both a historical and up-to-date understanding of the challenges faced by cotton farmers in this region. Precisely, this period did not only help to understand the immediate past conditions affecting cotton farming, but also provided the most recent information on climate conditions, agricultural outputs, and socio-economic status of smallholder cotton farmers.

1.8 The Conceptual Framework

The foundation of this study rested on three main ideas: the impact of climate change, the factors that make farmers vulnerable, and the strategies they use to adopt.

1.8.1 Climate Change Impacts

Inter-governmental Panel on Climate Change defines climate change impacts as the consequences of climate change on natural and human system (IPCC, 2014). In Kitgum District, small-scale cotton farmers are experiencing challenges due to climate change impacts. The challenges from climate change include unpredictable rainfall, increasing temperatures, more frequent extreme weather like droughts and floods, and pest problems. All of these factors are negatively impacting cotton yields and overall productivity, threatening the livelihoods of these farmers who depend on cotton farming.

1.8.2 Vulnerability of Smallholder Farmers

Vulnerability is the propensity of a system to be harmed by exposure to climate related hazards considering sensitivity and adaptive capacity (Atube et al, 2021). Smallholder cotton farmers are at risk from climate change impacts due to their exposure to hazards, the vulnerability of their crops, and their limited ability to adopt. Exposure means how often they face droughts or floods. Sensitivity refers to how much these events impact their cotton farming, based on factors like reliance on rainfall, limited irrigation, and temperature

sensitivity of the cotton. Adaptive capacity is their ability to adjust to climate change, based on their access to: Financial resources, Technology (e.g., better seeds, irrigation systems)

Climate information, Education and agricultural support services.

Furthermore, socio-economic factors like poverty, education levels, and access to markets also play a significant role in vulnerability, affecting farmers' ability to implement effective adaptation strategies.

1.8.3 Adaptation Strategies

Adaptation strategies are viewed as adjustment in human systems in response to actual or expected climate impacts (Kone et al, 2022). Smallholder cotton Farmers employ various techniques and strategies to adopt with the adverse impacts of climate change on agriculture. This research examined: adaptation practices, which are long-term strategies for increasing resilience; and institutional support, which included things like government programs and climate information access that help farmers adapt.

1.8.4 Relationships between Components

Climate change reduces agricultural production, which makes small-scale cotton farmers more vulnerable. Dependence on rain-fed cotton farming and exposure to climate-related challenges heighten farmers' vulnerability to the adverse effects of climate change. The ability to adapt is shaped by their adaptive capacity, which is determined by socioeconomic factors. Farmers with greater access to resources are better equipped to mitigate the impacts of climate change, while effective adaptation strategies enhance the resilience of small-scale farmers, thereby reducing their vulnerability.

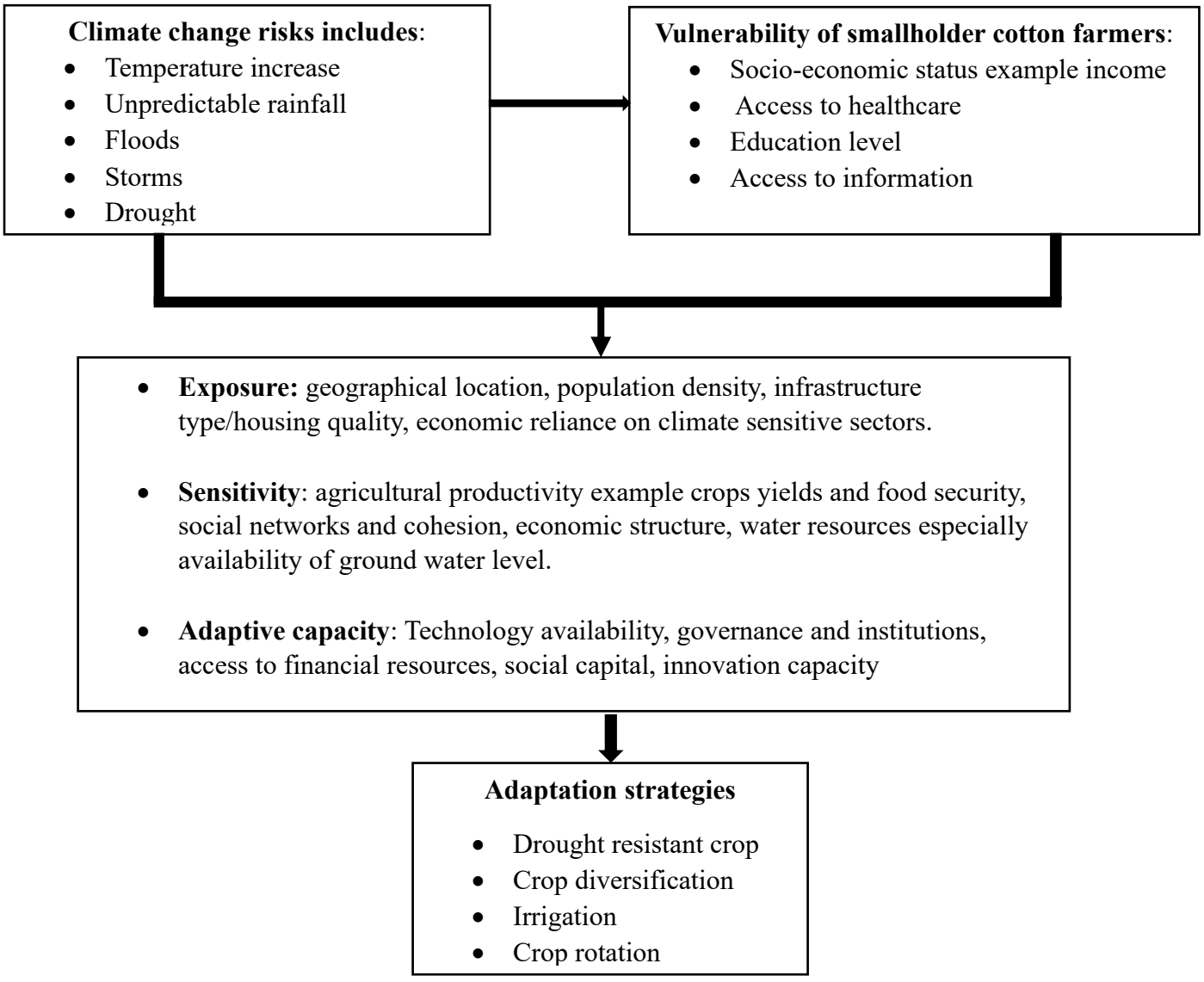
1.8.5 Theoretical Basis

It's based on well-known theories about climate vulnerability and resilience, especially the IPCC's framework. This framework identified exposure (how much climate change affects them), sensitivity (how much they are harmed by those effects), and adaptive capacity (their ability to adjust) as the crucial elements that determine how vulnerable they are to climate change.

This study used the IPCC's Vulnerability-Adaptation-Resilience (VAR) model, which defines vulnerability in terms of exposure, sensitivity, and adaptive capacity. It also draws on the

Sustainable Livelihoods Framework (SLF), which highlights the importance of socioeconomic factors in shaping farmers' adaptive abilities. Together, these frameworks provide a thorough way to examine how climate change, vulnerability, and adaptation strategies are related. By using this method, the study determined what smallholder cotton farmers in Kitgum District need to improve their resilience to climate change.

Figure 1: Conceptual framework



Adopted and modified from (Atube et al., 2021)

The conceptual framework shows that climate change (independent variables) impacts influence the vulnerability of smallholder cotton farmers(dependent variables) depending on the level of exposure, sensitivity and adaptive capacity (moderating factors). The level of vulnerability then determines the adaptation strategies employed by the smallholder cotton farmers to adopt to climate change impacts.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter explored existing literature on climate change-related risks, the vulnerability of smallholder cotton farmers, and the key factors shaping their susceptibility to climate change. The review incorporated insights from global, African, East African, Ugandan, and Northern Ugandan perspectives, with particular emphasis on the study's localized context in Northern Uganda.

2.1 Smallholder cotton farmers' perceived climate change-related risks

Climate change poses significant threats to smallholder cotton farming worldwide, impacting both production and livelihoods through rising temperatures, altered rainfall, increased pests and diseases, and water scarcity (Alotaibi, 2023). The UNFCCC highlights climate change as a major environmental challenge, triggering economic, health, food, and security crises. Climate change, driven by greenhouse gas emissions from human activities like fuel combustion and deforestation, is defined as alterations to the global atmosphere that exceed natural climate variability (Saleem et al., 2024).

In Africa, the effects of climate change are twofold, including direct impacts from extreme weather events and indirect effects from declining natural resource productivity due to issues like erosion and deforestation (Badji et al., 2022). Projections indicate that millions in African catchment areas will face increased risks of floods, droughts, and water scarcity, particularly affecting smallholder cotton farmers in marginalized areas.

Uganda's tropical climate is influenced by the El Niño Southern Oscillation (ENSO), leading to rainfall variability and extreme weather events like floods and droughts (Nsubuga & Rautenbach, 2018). While most of Uganda has two rainy seasons, the northern region experiences only one. Rising temperatures have led to a dramatic reduction in ice cover on the Rwenzori Mountains, potentially disrupting water supply systems and impacting agriculture and public health. Since the 1960s, (Nsubuga & Rautenbach, 2018) Uganda has experienced a 1.3°C rise in average temperatures, with more frequent hot days and nights.

Kitgum District receives an annual rainfall of 1,300mm, but there have been significant variations in temperatures and rainfall, with an overall increase in temperature and more

extreme weather events. Furthermore, (Nsubuga & Rautenbach, 2018) assert that smallholder cotton farmers are particularly affected by these changes.

Existing research indicates that small-scale farmers view climate change as a major threat due to erratic monsoon patterns and increased droughts (Alotaibi, 2023). They are also concerned about water availability and soil health. These farmers are especially vulnerable because their agricultural practices rely on consistent weather patterns, and they perceive risks such as changes in rainfall and rising temperatures (Badji et al., 2022).

According (Shoko Kori et al., 2024), smallholder cotton farmers in Africa face a myriad of challenges exacerbated by climate change, which significantly impacts their livelihoods. Africa's leading cotton producers-farmers have reported increasing variability in rainfall patterns, higher temperatures, and the prevalence of pests and diseases as major climate-related risks (Chakauya et al., 2023). These farmers perceive climate change as a direct threat to their crop yields and income stability. For instance, in Mali, farmers have noted that erratic rainfall has led to reduced planting opportunities and increased crop failure rates, prompting them to adapt their farming practices by shifting planting dates and diversifying crops(Mdoda et al., 2024).

Smallholder cotton farmers in Burkina Faso indicate concerns over the intensifying heat and its impact on soil moisture. Many farmers believe that rising temperatures have led to an increase in pest populations, which not only affects cotton yields but also raises the cost of production due to the need for more pesticides (Zinyemba et al., 2018). The perception of climate change as a risk factor has led farmers to seek training on integrated pest management and sustainable agricultural practices (Zinyemba et al., 2018). Furthermore, farmers in this region have reported that climate change is making traditional farming calendars obsolete, forcing them to rely on more flexible and adaptive strategies to manage their crops effectively.

According to Shingirai & Chitongo (2023), Tanzania's cotton farmers similarly perceive climate change as a critical risk to their agricultural practices. The farmers have observed shifts in weather patterns, particularly prolonged droughts and unpredictable rainfall, which have led to significant harvest losses (Irish Aid, 2018). Many smallholders express a sense of helplessness in the face of these changes, as they often lack access to climate-resilient seeds and technologies (C. & Sieber, 2015). This perception is compounded by limited access to financial resources and information, which further hinders their ability to adapt to changing

conditions(Mdoda et al., 2024). As a result, Tanzanian farmers are increasingly advocating for government support in developing climate-smart agriculture initiatives that can enhance their resilience.

However, perceptions of climate change risks among cotton farmers vary, with many echoing similar concerns about temperature increases, changing precipitation patterns, and pest outbreaks (Shoko Kori et al., 2024(Shoko Kori et al., 2024). In countries like India and the United States, farmers have reported similar challenges, leading to a growing recognition of the need for adaptive strategies. Indian cotton farmers, for instance, have begun adopting genetically modified cotton varieties that are more resilient to climate stresses, while U.S. farmers are investing in precision agriculture technologies to optimize water use and manage crop health (Ratakonda et al., 2024). The shared experiences of cotton farmers worldwide highlight the urgent need for collaborative efforts to address climate change impacts and enhance resilience in the cotton sector.

In conclusion, smallholder cotton farmers recognize various climate change-related risks that threaten their productivity and livelihoods, requiring targeted adaptation strategies. Hence, there was a need for localized research that focused specifically on the effects on smallholder cotton farmers in areas like Kitgum District, Uganda, to develop customized adaptation strategies.

2.1.1 Gaps in the literature

Although existing research on this objective covers the global and regional effects of climate change risks faced by smallholder farmers, clear shortage of localized studies that specifically examine smallholder cotton farmers perception in areas like Kitgum District, Uganda, exist. This indicates that the unique challenges and risks these farmers face might not be fully captured or addressed in broader analyses. Additionally, while climate change trends are discussed in the literature, there is a lack of in-depth temporal analysis that explores how smallholder cotton farmers' perceptions of climate-related risks have changed over time. Gaining insights into these temporal shifts could provide a better understanding of how farmers are adapting, or failing to adapt, to the ongoing climate changes.

2.2 The factors influencing the vulnerability of smallholder cotton farmers to climate change

The vulnerability of smallholder cotton farmers to climate change globally, across Africa, in Uganda, and especially in Northern Uganda, is shaped by various factors. These include environmental, socio-economic, institutional, and policy-related influences. Research highlights the importance of understanding these elements to formulate strategies that strengthen farmers' resilience. Key determinants include:

2.2.1 Environmental and Physical Factors

Scholars like (Mugaga, 2020) have identified climate variability and extreme weather events as key environmental factors contributing to the vulnerability of smallholder cotton farmers to climate change. Farmers are particularly susceptible to shifts in climate patterns, including irregular rainfall, extended droughts, and a rising frequency of extreme weather events such as floods and heat waves. These climatic changes can lead to reduced agricultural productivity, crop failures, and loss of income (Mugaga, 2020; IPCC, 2014). Similarly, soil fertility is essential for cotton production, and climate change can exacerbate soil degradation through increased erosion, nutrient depletion, and changes in soil moisture levels. Degraded soils reduce crop yields and the ability of farmers to sustain their livelihoods (IPCC, 2014). Additionally, access to water is critical for cotton farming. Studies indicate that climate change can alter precipitation patterns and increase evaporation rates, leading to water scarcity. Limited water availability affects crop growth and productivity, endangering the reliance by smallholder farmers on rain-fed agricultural practices (Oketcho Chombo et al., 2018).

2.2.2 Socio-Economic Factors

Various factors affect smallholder farmers' cotton farming, including financial resources, access to information, infrastructure, social networks, and education (van Asseldonk et al., 2023). Financial stability plays a key role in securing credit, insurance, and essential services for investing in climate-resilient practices and technologies (Dyanty et al., 2025). A lack of financial resources limits the implementation of adaptive strategies. Additionally, access to climate change information and agricultural extension services is vital for making informed decisions and adopting practices that mitigate the effects of climate change.

Infrastructure, such as irrigation systems and transportation networks, is vital for building resilience, but poor infrastructure limits farmers' responses to climate variability and reduces market access increasing their vulnerability. Social networks and community support systems play a significant role in influencing the level of smallholder cotton farmer's vulnerability (Oketcho Chombo et al., 2018) Additionally, education and skills development are vital for adopting new technologies and adaptive practices, with higher education levels and targeted training improving farmers' capacity to address climate change challenges effectively.

2.2.3 Institutional and Policy Factors

According to (Mugagga et al., 2020), effective governance and supportive policy frameworks are essential for addressing the vulnerability of smallholder farmers. Policies that promote sustainable agricultural practices, provide financial incentives, and support climate adaptation initiatives can significantly reduce vulnerability. Equally, (Mugagga et al., 2020) identified the level of external assistance, including support from government agencies, non-governmental organizations, and international bodies, as another factor that can influence smallholder farmers' adaptive capacity. External assistance can provide financial aid, technical support, and resources necessary for implementing adaptation measures reducing their level of vulnerability(Oketcho Chombo et al., 2018).

In most cotton growing districts of Uganda including Kitgum District, soil degradation and water scarcity have been the leading determinants regarding this phenomenon. Specifically, (Mugisho et al., 2024) observed that soil fertility is essential for cotton production, and climate change can exacerbate soil degradation through increased erosion, nutrient depletion, and changes in soil moisture levels. Degraded soil reduces crop yields and the ability of farmers to sustain their livelihoods. Likewise, access to water is critical for cotton farming. Climate change can alter precipitation patterns and increase evaporation rates, leading to water scarcity(Jamshidi et al., 2019). Limited water availability affects crop growth and productivity, posing a threat to the final output and earnings for the smallholder farmers (Tukezibwa, 2010).

Research indicates that access to information and agricultural extension services significantly influences the vulnerability of smallholder cotton farmers in northern Uganda to climate change. A lack of access to agricultural extension services and climate-related information hinders their ability to make informed decisions and adopt mitigating practices(Mutengwa et

al., 2023; Opoku Mensah et al., 2025). External support from government agencies, NGOs, and international organizations is crucial for enhancing their adaptive capacity by providing financial resources, technical assistance, and other necessary tools.

In summary, despite general research on the vulnerability of smallholder farmers to climate change, there is a lack of localized studies specifically focused on the effects on cotton farmers in Kitgum District and Northern Uganda. Most current research takes a broad approach and does not investigate the specific challenges and adaptive capacities faced by smallholder cotton farmers in particular sub-counties. Furthermore, existing literature often overlooks the cultural and socio-economic factors that affect these farmers' vulnerability and their ability to adapt. There was a significant need for in-depth studies that explore how social structures, cultural practices, and economic conditions influence farmers' responses to climate change.

2.2.4 Cultural and Social Factors

Scholars, such as (Chombo, 2018),have noted that strong social networks and community cohesion can promote collective action, as well as the sharing of resources and information, which helps reduce vulnerability. Likewise, cultural practices and beliefs can shape farming practices and responses to climate change. Traditional practices may either strengthen resilience or heighten vulnerability, depending on their effectiveness in adapting to changing climate conditions (Nyong et al., 2007).

2.2.5 Gaps in the literature

While governance and policy frameworks are recognized for reducing vulnerability, there is a lack of research on the specific policies and support systems for smallholder cotton farmers in Kitgum District. More detailed evaluations of these policies are needed. Additionally, the connection between climate vulnerabilities and non-climatic factors such as poverty, governance, market access, and infrastructure need further exploration. This study intended to fill this gap by examining how these combined factors affect the vulnerability of smallholder cotton farmers.

2.3 The adaptation strategies employed by smallholder cotton farmers to lessen the impacts of climate change

Adaptation strategies are adjustments in a system in response to the actual or expected climate impacts (Kone et al, 2022) and implement measures to prevent harm or broaden its tolerance range, influenced by factors like income, education, information access, and infrastructure (Oketcho Chombo et al., 2018) Some factors can reflect both exposure and sensitivity, and sensitivity combined with adaptive capacity can represent social vulnerability.

Improving adaptation strategies is crucial for policy development, reducing sensitivity and overall vulnerability. Many indigenous communities demonstrate high adaptive capacity through traditional knowledge developed over generations (Belay et al., 2017). In the Ethiopian highlands, smallholder farmers remain vulnerable due to challenges in effectively implementing available adaptation measures, as limited access to finance, information, and technology constrains their ability to fully adapt (Belay et al., 2017). Therefore, efforts must focus on enhancing farmers' ability to adopt both individual and government-supported climate adaptation approaches.

Many farmers have low adaptive capacity, as minimizing risks requires technology such as drainage systems and irrigation. This leaves smallholder cotton farmers vulnerable, and this study aims to assess their vulnerability to inform policymakers. Smallholder cotton farmers often face significant challenges due to climate change, which affects their productivity and livelihoods (Makuvaro et al., 2014). Adaptive capacity refers to the ability of these farmers to adjust their practices and strategies in response to changing climatic conditions. Research indicates that smallholder farmers employ a variety of adaptive strategies, including diversifying crop varieties, altering planting dates, and adopting integrated pest management techniques (Wo, 2010). These adaptations are crucial for maintaining yields in the face of unpredictable weather patterns, such as droughts or excessive rainfall.

Additionally, access to information and technology plays a vital role in enhancing the adaptation strategies of smallholder farmers (Ewulo et al., 2025). Programs that provide weather forecasts, climate-smart agriculture training, and access to drought-resistant seed varieties empower farmers to make informed decisions (Ewulo et al., 2025). Community-based approaches, where farmers share knowledge and experiences, have also proven effective in building resilience. Studies have shown that when farmers collaborate and learn from one another, they are better equipped to face the challenges posed by climate change.

Coping mechanisms refer to the immediate responses that smallholder cotton farmers adopt to deal with the adverse effects of climate change (Ngetich et al., 2022). These mechanisms often include short-term strategies aimed at minimizing losses during extreme weather events. For example, farmers may resort to selling livestock or other assets to cope with financial losses incurred from crop failures. This reactive approach, while sometimes necessary, can lead to long-term vulnerabilities as it depletes the resources that farmers rely on for their livelihoods (Ngetich et al., 2022).

Moreover, smallholder farmers often engage in crop rotation and intercropping as coping strategies to mitigate the impacts of climate variability (Ngetich et al., 2022). By planting a variety of crops, farmers can reduce the risk of total crop failure due to pests or unfavorable weather conditions. This diversification not only helps stabilize income but also enhances soil health and fertility, contributing to more sustainable farming practices. Research has shown that these adaptation strategies can be effective in the short term but may need to be complemented with long-term measures to ensure sustainability.

2.3.1 Gaps in the literature

Although the existing literature recognizes the adaptation strategies and climate change vulnerability of farmers, there is a significant gap in detailed, localized studies that focus specifically on smallholder cotton farmers in Kitgum District and Northern Uganda. Much of the current research provides broad assessments that fall short of addressing the particular difficulties and adaptation strategies of these farmers. More research was needed to understand how well traditional practices and other adaptation strategies work in response to climate change impact. Studies should focus on whether these practices help farmers become more resilient or make them more vulnerable, so that adaptation strategies can be tailored to local cultures and contexts.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the research methods used in the study, covering the research design, study area, target population, sample size, data collection techniques and tools, the validity and reliability of data collection instruments, and ethical considerations.

3.1 Research Approach

This study employed a mixed-methods approach, integrating both quantitative and qualitative research techniques (Aspers & Corte, 2019). The mixed-methods approach was chosen to capture the complexity of vulnerability by combining statistical analysis with in-depth contextual understanding. The Qualitative approach is an interactive process that involves examining and analyzing people's ideas, feelings, and perceptions to derive meaning in line with the problem under investigation (Aspers & Corte, 2019). This enriched the study with qualitative aspects regarding smallholder cotton farmers' perceived climate change related risks in selected sub-counties of Kitgum District. The quantitative approach employed basic statistical methods to determine the extent of smallholder cotton farmers' vulnerability to climate change and identify the factors contributing to their vulnerability in selected sub-counties of Kitgum District.

3.2 Research Design

This study adopted a descriptive research design to assess and characterize the vulnerability of smallholder cotton farmers to climate change and climate variability (Islamiia, 2016). Descriptive research aimed to illustrate the attributes of a population or phenomenon, offering a comprehensive understanding of the subject (Boru, 2018). It was particularly useful for examining the various factors influencing specific issues, such as environmental, socio-economic, and agricultural practices affecting farmers. Therefore, this research design was well-suited for the study, as it enabled a detailed analysis of smallholder cotton farmers' vulnerability, supported the collection of baseline data, and provided critical insights to inform future interventions and policy decisions.

3.3 Study Area

This research concentrated on selected sub-counties within the Kitgum District in Northern Uganda, an area situated between longitudes 32°E and 34°E and latitudes 2°N and 4°N. Part of the Acholi sub-region, Kitgum District covers 4,042 km2 and has a population of 239,386 (Okwera, 2021). Kitgum is located North-East of Gulu, and approximately 460 kilometers North of Kampala. The district is bordered by Lamwo district to the Northwest, South Sudan to the North , Karenga and Kotido to the East, Agago to the South, and Pader to the Southwest. The district comprises two counties, ten sub-counties, 55 parishes, and 863 villages (Aloyo et al., 2024).

The vegetation of Kitgum district is mainly woody savanna consisting of scattered trees and grasses. Common grass species include thatching grass (Hyparrhenia Rufa), Guinea grass (Panicum maximum), beard grass (Brachiaria brizantha) among others(Kitgum District Local Government, 2021).

Kitgum district has a tropical savanna climate with distinct wet and dry seasons. The average annual rainfall is about 1260-1300mm and the rainfall pattern is bimodal with peaks in April and August. Rainfall begins in late march or early April and continues until November with a short dry spell around June. The dry season extends from December to id-march and is generally hot, dry and windy (Aloyo et al, 2024).

The dominant soils are well-drained sandy clay loams soil which support crop production of crops like cotton, maize, sorghum, millet and simsim among others(Kitgum District Local Government, 2021). Soil fertility varies across the district making good soil management practices such as crop rotation important for sustainable agriculture (Onek, 2016).

However, agricultural productivity is declining due to the effects of climate change and declining soil fertility. According to (Onek, 2016), the district is characterized by a predominantly agrarian economy, with cotton farming being a significant agricultural activity. According to cotton development organization (CDO, 2024), over 4800 households are engaged in cotton farming out of 56,706 households (UBOS, 2024). The sub-counties were selected based on their high levels of productivity in cotton farming and their varying degrees of exposure to climate change impacts. The study focused on three sub-counties: Omiya-Anyima, Kitgum Matidi, and Lagoro.

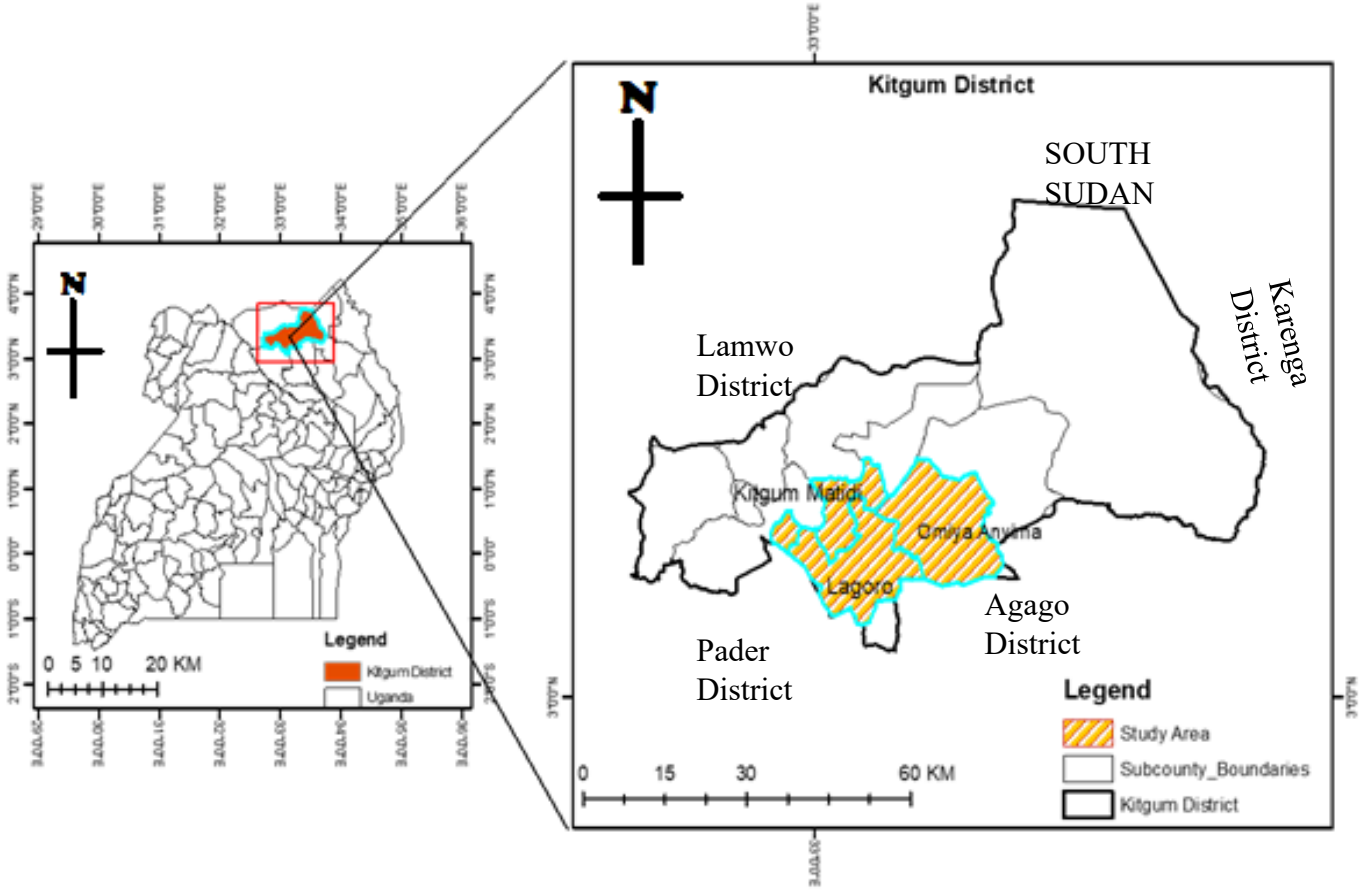


Figure 2: A Map of Kitgum Showing the Selected Sub-Counties of the Study

3.4 Target Population

The target population was determined based on the study objectives and the characteristics of the people directly affected by the phenomena under investigation. The most relevant people to the research objective were identified and their total number was obtained from official record of cotton development organization office.

The study comprised the following categories of the target population:

Smallholder Cotton Farmers and household members. This encompassed all smallholder cotton farmers in the selected sub-counties of Kitgum District who are engaged in cotton farming. These farmers typically cultivate less than 05 hectares of land and rely on family labor for agricultural activities. Factors such as age, gender, education level, and land size were considered (Mwongera et al., 2014). The study also focused on household members involved in smallholder cotton farming, as they participate in farming activities and are affected by climate change impacts. These also included dependents affected by agricultural productivity and household income.

Agricultural Extension Officers: Professionals who provide technical support and advisory services to the farmers. Their insights on farmers' practices and adaptation strategies were crucial. These included officers assigned to the selected sub-counties, their role, and frequency of interaction with smallholder cotton farmers.

Local Government Officials: Authorities involved in agricultural and environmental planning and policy-making in Kitgum District. This study included District Agricultural Officers and environmental department staff due to their involvement in climate change adaptation policies.

Additionally, representatives from NGOs working on climate change adaptation, agriculture, and rural development in the region, specifically those operating in the selected sub-counties, were included. An example of such NGO was the Gulu Agricultural Development Company (GADC), Cotton Development Organization (CDO) and East Acholi Cooperative Union (EACU) due to the programs and support it provides to smallholder cotton farmers.

3.5 Sampling Techniques and Sample Size

3.5.1 Sampling techniques

Multistage sampling and snow balling was used to select cotton farming households from the selected sub-counties and villages. This was meant to distribute farmers across the three sub-counties while maintaining representativeness (Leedy, P.D. Ormrod, 2015). The Snowball sampling method was to ensure that people with the same traits are identified and selected in the different sub-counties. Besides, it is cost-effective as it relies on referrals.

For other study populations, purposive sampling was used to select key informants and experts relevant to the study. Specifically, purposive sampling deals with respondents who have the knowledge for the study under inquiry (Boru, 2018). Therefore, these included extension officers, local officials, and NGO representatives.

3.5.2 The sample size

The sample size for this study was calculated using Yamane's formula, which is appropriate for finite and heterogeneous populations like the smallholder cotton farmers in this study. The formula provided a reasonable sample size for studying the population and is easy to use compared to other methods(Aspers & Corte, 2019).

The Taro Yamane formula is given as: n =N/1+N(e)2.

Where:

n =the sample size

N=the finite population

e=the error/the limit of tolerable error, which is 10%.

1=a constant value

Table 1: Sampling Frame, Sample Size, and Distribution

Category of respondent	**Target population**	**Sample size**	**Sampling techniques**
Smallholder cotton farmers in three sub-counties	4009	279	Snowballing
Selected sub-counties			
Omiya-Anyima	1235	92	Snowballing
Kitgum-Matidi	1472	94	Snowballing
Lagoro	1302	93	Snowballing
Agricultural extension workers	03	03	Purposive sampling
Non-governmental organization	03	03	Purposive sampling
FGD participants	06	06	Purposive sampling
TOTAL	4018	291	

Source: Secondary data (2024).

From the above table, the study targeted a total sample size of approximately 291 participants, distributed across the selected sub-counties considering different categories to ensure comprehensive and diverse data collection. However, 210 participants took part in this study, giving a response rate of 72% and a non-response rate of approximately 28%. The majority of the sample consisted of smallholder cotton farmers, with one member selected per cotton farming household to capture the primary focus of the research.

3.6 Data Collection Method and Tools

3.6.1 Objective 1. To assess smallholder cotton farmers' perceived climate change risks in Kitgum District

Research questions. What are the perceived climate change risks of smallholder cotton farmers in Kitgum District?

3.6.1.1 Household farmers Surveys using structured questionnaires.

These concentrated on particular elements of the phenomenon being investigated and utilized a structured questionnaire administered to a sample of smallholder cotton farming households. The questionnaire included both open-ended and closed-ended questions take approximately 10 to 20 minutes to complete.

The questionnaire covered:

1. Demographic Information: Age, gender, education level, household size, etc.
2. Agricultural Practices: Land size, types of crops grown, farming methods, input usage.
3. Climate Change Perception: Farmers' awareness and perception of climate change impacts.
4. Exposure: Frequency and extent of events related to climate (e.g., floods and droughts).
5. Sensitivity: Impact of climate events on cotton production and income
6. Adaptive Capacity: Access to resources, access to technology, social capital, extension services, climate information, and adaptive strategies employed.

3.6.1.2 Agricultural Productivity Data Collection

Secondary data on cotton yields was collected from smallholder cotton farmers, district agricultural offices, and non-governmental organizations dealing with cotton farmers, and local farmer cooperatives over the last 10 years. Additionally, field surveys were conducted to gather primary data on crop yields, planting, and harvesting trends from smallholder cotton farmers.

3.6.1.3 Interviewing Method using key informant interview guides

To collect additional information from other target populations, for example, Agricultural Extension Officer (AEO), Non-Governmental Organization (NGO), and other key informants, the researcher employed the interview method.

3.6.2 Objective 2: To identify the factors influencing smallholder cotton farmers' vulnerability to climate change in Kitgum District

Research Question: What are the factors influencing smallholder cotton farmers' vulnerability to climate change in Kitgum District?

3.6.2.1 Household survey using detailed structured questionnaires

This was administered to a sample of smallholder cotton farming households. It consisted of both open-ended and closed-ended questions, which lasted between 10 - 20 minutes. The questionnaire covered:

Demographic Information: Age, gender, education level, household size, etc.

Agricultural Practices: Land size, types of crops grown, farming methods, input usage.
Climate Change Perception: Farmers' awareness and perception of climate change impacts.
Access to financial services (loans, savings).
Access to agricultural inputs (seeds, fertilizers, pesticides).
Participation in cooperatives or farmer groups.

3.6.2.2 Farmers' Vulnerability assessment using composite vulnerability index/framework

A composite vulnerability index was constructed using indicators of exposure, sensitivity, and adaptive capacity to assess farmer vulnerability to climate change. Particularly, an integrated vulnerability index type that typically combines indicators from social, economic, and environmental domains was used to give a comprehensive measure of vulnerability. The weighting and aggregation method used predetermined weights that were assigned to indicators based on expert judgment.

3.6.2.3 Key Informant Interviews (KIIs) using interview guides

Interviews were conducted to 5 key informants which included District Agricultural Officer/production Officer, 1extension worker and 3 NGO representatives which included EACU, CDO and GADC to understand the broader socio-economic context and any external factors influencing farmers' vulnerability to climate change

3.6.3 Objective 3: To assess the adaptation strategies employed by smallholder cotton farmers to adopt to the impacts of climate change in Kitgum District

Research Question: What are the adaptation strategies employed by smallholder cotton farmers in Kitgum District to adopt to the impacts of climate change?

3.6.3.1 Farmer Surveys using structured questionnaires and interview guides

A structured survey was developed to gather information on the adaptation strategies employed by farmers in response to climate change risks. Questions covered areas of crop rotation, usage of drought-resistant cotton varieties, irrigation, soil conservation, and early warning systems.

3.6.3.2 Focus Group Discussions (FGDs) using FGD guides

One FGD involving 7 participants from the 3 sub-counties was conducted in Kitgum Matidi to gain deeper insights into communal adaptation strategies, farmer perceptions, and the

effectiveness of different strategies used and it covered areas of crop rotation, usage of drought-resistant cotton varieties, irrigation, soil conservation, and early warning systems.

3.6.3.3 Case Study Approach using Discussion Guides

A few farmers who had successfully implemented adaptation strategies were selected and used as case studies. Their practices, costs, benefits, and challenges in implementing these strategies were documented.

3.6.3.4 Assessment of Institutional Support using key informant interview guides

Key stakeholders (e.g., local agricultural extension officers, NGOs, farmer cooperatives) were interviewed to understand the external support farmers received for climate adaptation (e.g., training, access to improved seeds, and financial assistance).

3.7 Data Analysis Method

3.7.1 Objective 1. Descriptive Statistic and thematic analysis

A descriptive statistical tool such as SPSS was used to analyze the perception of farmers to climate change risk. This involved using percentage informs of graphs and charts for visualization of farmers perception and concerned about climate change risk.

Thematic content analysis was used to analyze the qualitative data to provide context and deeper insights on the perception of farmers basing on the frequency of themes such as: climate awareness, climate concern, climate impact among others. By triangulating a comprehensive understanding of how farmers perceive climate change and the factors influencing their risk assessments, ultimately facilitate more informed decision-making and targeted adaptation strategies.

3.7.2 Objective 2. Descriptive statistical tools

Descriptive statistical tools, such as coefficient of variation and standard deviation used to provide a meaningful summary of the adaptation strategies employed by farmers. The effectiveness of different adaptation strategies was analyzed based on farmer-reported outcomes (e.g., yield stability, reduction in losses due to climate events).

3.7.3 Objective 3. Pearson correlation coefficiency, SPSS and composite vulnerability index Pearson correlation 2 tailed was used to analyze the factors influencing the vulnerability of smallholder cotton farmers.

The relationships among various factors and farmer vulnerability were determined in SPSS in which frequency and percentages was used to determine which factors (e.g., income, education) significantly affect vulnerability.

Additionally, the level of vulnerability was assessed using a composite vulnerability index based on four levels: 1 (low)), 2 (very low)), 3 (high) and 4 (very high). A composite vulnerability index was constructed using indicators of exposure, sensitivity, and adaptive capacity to assess farmer vulnerability to climate change. The vulnerability index typically combines indicators from social, economic, and environmental domains to give a comprehensive measure of vulnerability.

3.8 Ethical Considerations

This pertained to the degree of awareness and scrutiny applied to both personal and professional actions throughout the research process (Fleming & Zegwaard, 2018). Hence, the study adhered to the following procedures: Informed Consent: Participants were thoroughly briefed on the study's objectives, and their consent was secured before they took part. Privacy: The information gathered from participants will be kept confidential and will be used solely for this research. Ethical Approval: The study sought ethical approval from the relevant authorities and institutional review boards, where applicable, and finally it was approved GUREC-2024-1002 as the approval number.

3.9 Limitations

The study was limited by the following inevitable circumstances;

Data Accuracy: The use of self-reported data in surveys could have led to some potential bias. However, this was reduced by use of validated and reliable data collection instruments and use of appropriate statistical methods and software to reduced analytical errors. Scope: The study was limited to specific sub-counties of Omiya-Anyima, Kitgum-Matidi, and Lagoro, which means generalization of the findings is only possible in other regions with similar socio - economic and environmental settings.

CHAPTER FOUR

PRESENTATION OF RESULTS

4.1 Socio-economic and demographic Characteristics of Study Respondents

The socio demographic and socioeconomic characteristics of study participants are presented in Table 2. The results show that most respondents (39%) were aged between 21-30 years. A significant proportion (54%) of respondents were males. Most smallholder cotton farmers (47%) had attained a primary level of education. the majority of smallholder cotton farmers (48%) had less than five years of experience in cotton farming. Gossypium hirsutum (upland cotton) was grown by most smallholder cotton farmers (47%). The results further showed that most smallholder cotton farmers (74%) had less than 15 acres of land. In the same vein, a significant proportion of smallholder cotton farmers (65%) allocated less than three acres of land to cotton farming. Most smallholder cotton farmers (50%) used hired labor for cotton farming activities. A significant proportion of smallholder cotton farmers (88%) had other occupations. However, most smallholder cotton farmers (56%) earned less than 100,000 Ugx from other income-earning activities. The results also reveal that most smallholder cotton farmers (69%) were members of a social or community self-help organization. A significant proportion of smallholder cotton farmers (55%) reported that there were no cotton farmers' groups available in their locality. Similarly, a significant proportion of smallholder cotton farmers (94%) did not have access to any benefactor remittances or support.

Table 2: Socio-economic and demographic Characteristics of Respondents

Variable		Frequency (N = 188)	Percentage (%)
Age	21 - 30 years	103	54
	31 - 40 years	41	22
	41 - 50 years	28	15
	Above 50 years	16	9
Gender	Male	102	54
	Female	86	46
Level of education	No formal education	43	23
	Primary education	88	47
	Secondary education	52	28
	Tertiary education	5	3
Cotton farming experience	Less than 5 years	90	48
	5 - 10 years	51	27
	11 - 15 years	24	13
	Above 15 years	23	12
Type of cotton grown	Gossypium hirsutum (upland cotton)	88	47
	Gossypium barbadense (Egyptian cotton)	9	5
	Hybrid varieties	13	7
	Don't know	78	42
Land size	Less than 15 acres	139	74
	Greater than 15 acres	49	26
Land size allocated for cotton farming	Less than 3 acres	122	65
	3 - 5 acres	54	29
	6 - 10 acres	9	5
	More than 10 acres	3	2
Labour source	Family labour	93	49
	Hired labour	95	50
Other occupation	No	22	12
	Yes	166	88
Average monthly income from other sources	Less than 100,000 Ugx	105	56
	Between 100,000 - 200,000 Ugx	29	15
	Between 200,000 - 500,000 Ugx	22	12
	Above 500,000 Ugx	10	5
Social/community self-help group membership	No	129	69
	Yes	59	31
Cotton farmers' group availability	No	103	55
	Yes	85	45
Benefactor remittance/support	No	176	94
	Yes	12	6

4.2 Smallholder Cotton Farmers' Perceived Climate Change Risks

4.2.1 Perceived Weather Changes

The perceived weather changes experienced by smallholder cotton farmers are presented in Table 3 below. The results show that a significant proportion (97%) of smallholder cotton farmers noticed changes in weather patterns. The major noticeable weather changes observed by smallholder cotton farmers were unpredictable rainfall (75%). The results also indicate that the majority (51%) of smallholder cotton farmers noticed these weather changes every two years. The findings also reveal that most smallholder farmers (90%) believed that the changes in weather patterns impacted cotton farming activities.

Table 3: Smallholder Cotton Farmers' Perceived Changes in Weather

Variable		Frequency (N)	Percentage (%)
Changes in Weather patterns noticed	No	5	3
	Yes	**183**	**97**
Weather changes noticed	**Unpredictable Rainfall**	**135**	**75**
	Prolonged Drought	**90**	**50**
	Increased flood frequency	45	25
	Storm occurrence	22	12
Frequency of Changes	Every year	76	42
	After every 2 years	93	51
	After 5 years	10	6
	After 10 years	4	2
Changes in Weather Patterns Impact Cotton Farming Activities	No	18	10
	Yes	**170**	**90**

4.2.2 Smallholder Cotton Farmers' Perceived Climate Changes

The perceived climate changes among smallholder cotton farmers are presented in Figures 3 and 4 in page 29. The results show that most smallholder cotton farmers (86%) observed the occurrence of climate change in the last 10 years (Figure 3). The results show that most smallholder cotton farmers (67%) were either concerned (42%) or very concerned (25%) about the occurrence of climate change (Figure 4). This was further confirmed during a key informant interview, where a key informant said;

"…… The problem of climate change is not only a concern to the farmers but to all, because climate change not only affects agriculture or cotton farming but all other sectors either directly or indirectly." (Said the Key informant, 2024)

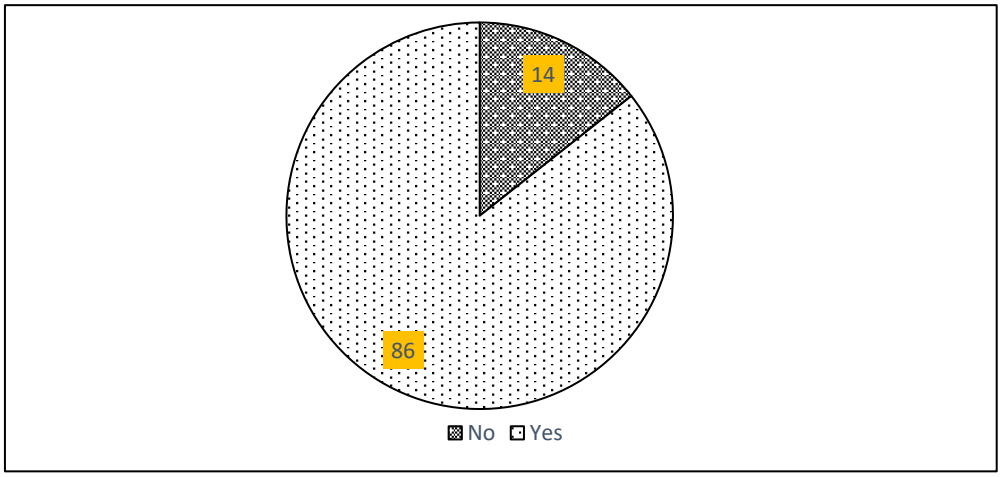


Figure 3: Occurrence of Climate Change in the Last 10 Years

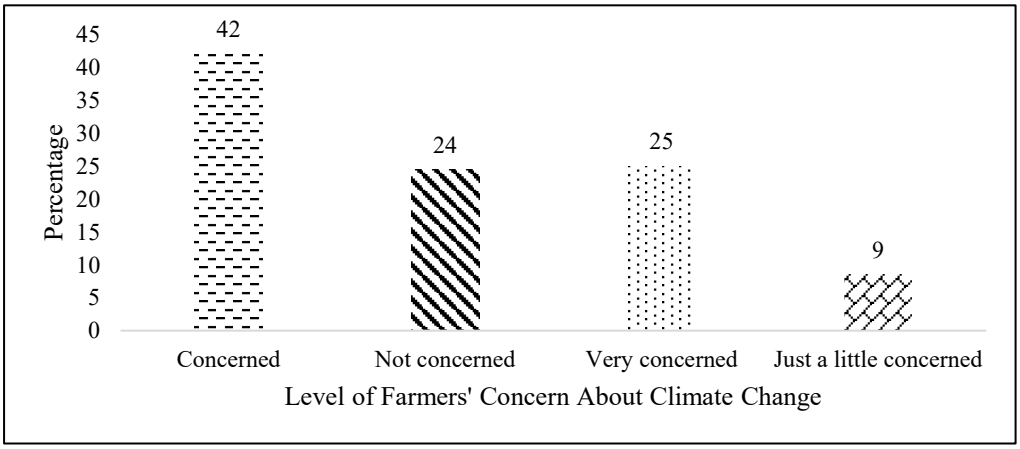


Figure 4: Extent of Concern About Climate Change

The results in table 4 (page 30) show that most smallholder cotton farmers (71%) experienced changes related to climate with most smallholder cotton farmers (53%) experiencing prolonged drought as a major climate change risk. The majority of smallholder cotton farmers (46%) reported that climate change had very severe effects on cotton farming activities. In the same vein, most smallholder cotton farmers (88%) noted that climate change affected cotton crops. Key impacts on cotton quality and productivity were reported.

Table 4: Climate Changes and Associated Effects Experienced by Smallholder Cotton

Variable		Frequency (N)	Percentage (%)
Experienced any significant changes related to climate	No	55	29
	Yes	**133**	**71**
Climate Change Risks Experienced	Temperature increase	23	8
	Rainfall decreases	65	27
	Prolonged drought	**84**	**35**
	Pests and diseases	65	27
Severity of Climate Change on Cotton Farming Activities	Not severe	13	8
	Moderately severe	73	43
	Very severe	78	46
	Extremely severe	6	4
Climate Change on effects Cotton Crop	No	22	12
	Yes	**166**	**88**
Frequency of Crop Failures Experienced Due to Climate Change	Never	25	13
	Rarely - Once every 5 - 10 years	51	27
	Occasionally - Once every 2 - 4 years	59	31
	Frequently - Once a year	22	12
	Always - every season	31	17
How Cotton is Affected by Climate Change	**Poor-quality**	**98**	**34**
	Reduced yields	**118**	**41**
	Crop loss	70	24
Climate change effects on cotton farming income	No effect	16	9
	Slightly reduces income	**64**	**34**
	Moderately reduces income	25	13
	Significantly reduces income	36	19
	Severely reduces income	47	25
Climate Change Effects on Livelihoods	Debt	79	28
	Food insecurity	**131**	**48**
	Poor health	32	12
	School dropouts	32	12

Climate variability occurred occasionally, that is, once every 2 – 4 years. It is also apparent that most smallholder farmers (41%) reported that climate change reduced cotton yields and the effect also extends to the household income and livelihoods. It is also evident that most smallholder farmers (34%) noted that climate change slightly reduced their income earnings from cotton farming. Additionally, a significant proportion of respondents (48%) experienced food insecurity as a major climate change impact on their livelihoods.

The impact of climate change on the quality of cotton was further revealed by a lead farmer during a focus group discussion that;

"……extremes events such as heavy rainfall and wet conditions during harvesting stain the cotton lint reducing its grade and market value." (Said a participant in FGD 2024)

This was witnessed through observation when a researcher visited a cotton store and the lead farmer who owns the store revealed the poor-quality grade due to the stained color caused by heavy rainfall as seen in the photo (figure 5) below.



Source: Photo Field (2024)

Figure 5: Poor quality grade of cotton

4.3 The adaptation Strategies Used by Smallholder Cotton Farmers to Adapt to the Impacts of Climate Change

The different adaptation strategies used by smallholder cotton farmers to adapt to climate change are presented in Figures 6 and 7 (page 32).

The results in Figure 6 indicate that most farmers (38%) used drought-resistant seeds to cope with climate change risks. The results also indicate that most farmers are unable to use irrigation due to limited resources to acquire irrigation machines.

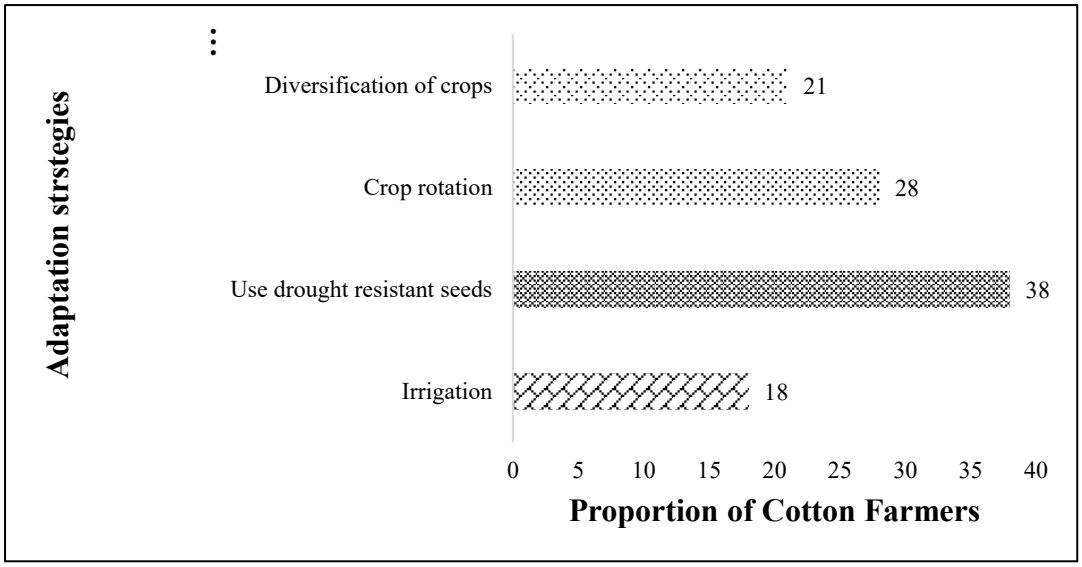


Figure 6: Strategies Adopted by Smallholder Cotton Farmers to Cope with Climate Change

In Figure 7, it is apparent that most smallholder cotton farmers (75%) believed that having access to financial assistance and resources would boost their capacity to adapt to climate change while some farmers (64%) believed that trainings on climate smart agriculture would help them cope with the impact of climate.

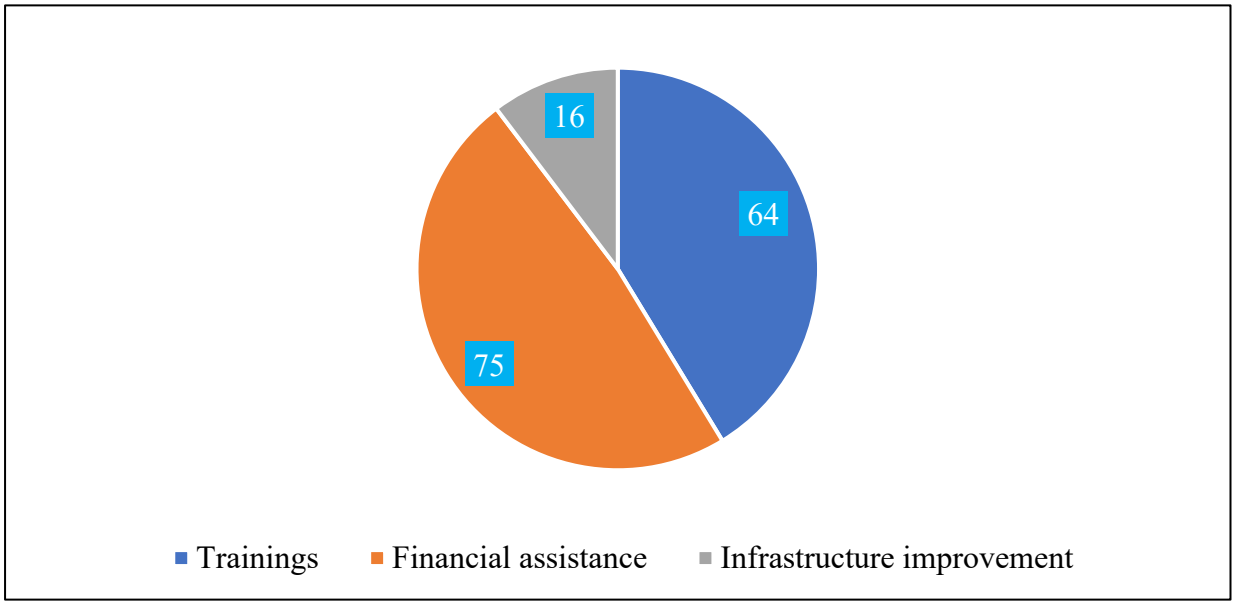


Figure 7: Strategies Proposed to Boost Adaptation Capacities of Smallholder Cotton Farmers to Climate Change

4.4 Factors Influencing Vulnerability of Smallholder Cotton Farmers to Climate Change

Pearson correlation analysis (Table 5 page 34) reveals several essential relationships regarding vulnerability factors affecting farmers' climate adaptation capacity. The strongest relationship emerges between community climate impacts and economic hardships ($r=.658$, $p<.01$), demonstrating how climate shocks translate directly into financial struggles for farming households. This economic vulnerability is further compounded by the positive correlation between economic hardships and adaptation hindrances ($r=.352$, $p<.01$), suggesting that financial stress creates significant barriers to effective climate adaptation increasing farmers vulnerability.

Institutional support systems show complex dynamics. While financial access correlates positively with support received ($r=.455$, $p<.01$), the type of support shows a negative relationship with adaptation hindrances ($r=-.383$, $p<.01$), indicating that well-targeted assistance can effectively reduce barriers. However, the negative correlation between support received and extension service effectiveness ($r=-.270$, $p<.01$) reveals a potential trade-off, where formal support systems may unintentionally undermine existing agricultural extension networks.

Community-level factors demonstrate dual effects, with community social factors showing positive associations with both adaptation support ($r=.352$, $p<.01$) and hindrances ($r=.324$, $p<.01$). This paradox suggests that while strong community networks facilitate some aspects of adaptation, they may also make farmers more aware of systemic constraints. The challenges faced by farmers show weaker but still significant correlations with both community impacts ($r=.240$, $p<.01$) and adaptation hindrances ($r=.226$, $p<.01$), indicating that perceived problems align with actual climate vulnerabilities.

Financial factors present mixed results. While financial access shows expected positive relationships with support systems, general financial challenges demonstrate no significant correlations with other variables, suggesting that specific financial constraints may be more important than overall financial difficulties in shaping adaptation outcomes. The analysis highlights how economic, institutional, and community factors interact in complex ways to shape farmers' vulnerability to climate change, with financial stress and institutional effectiveness emerging as particularly critical determinants of adaptive capacity. This was hinted during a focus group discussion where a participant revealed that;

"…. farmers who are financially weak faced more challenges, including pests and diseases, because they are not able to purchase the pesticides for spraying their crops, making them more vulnerable". (Said a participant of FGD 2024).

Table 5: Correlations among Vulnerability-Influencing Factors

Variables	1	2	3	4	5	6	7	8	9	10
1. Challenges faced	—	.240**	.137	.145	-.058	-.097	-.162	.154	.070	.226**
2. Community impact		**—**	**.658****	**.078**	**.079**	**.173***	**-.221****	**-.046**	**.352****	**.539****
3. Economic hardships	**—**	**.104**	**.156***	**.194***	**-.102**	**-.078**	**.289****	**.352****		
4. Financial challenges	—	.003	-.013	-.126	-.026	-.093	-.033			
5. Financial access	**—**	**.455****	**.148**	**-.022**	**.085**	**.014**				
6. Support received	**—**	**.379****	**-.270****	**.097**	**-.130**					
7. Type of support	—	-.201*	.061	-.383**						
8. Extension services	—	-.133	.248**							
9. Community factors	—	.324**								
10. Adaptation hindrances	—									

Notes: *p < .05, **p < .01 (2-tailed)

From the results in Table 6 (page 35), economic challenges (59%) were the main problems that increased smallholder cotton farmers' vulnerability to climate change. The results also show that most smallholder cotton farmers (71%) were affected by these challenges. It is also evident from the results that a significant proportion of smallholder cotton farmers (84%) faced economic hardships. The results also show that most respondents (74%) did not access financial resources such as loans and savings to invest in climate adaptation measures. This was confirmed during a focus group discussion where a member stated that:

"……. farmers who have limited capital are the most affected by cotton diseases because they are unable to spray their crop, and when the nearby garden is sprayed, the pest shifts to their garden, leading to loss

of their crop and low yield" (said a member of FGD, 2024)

Most respondents (60%) received support, especially training and education (60%), from Government & Other Stakeholders. Access to agricultural extension services did not have an influence on the ability of most cotton farmers (31%) to adapt to climate change. This was further revealed by a key informant during an interview that;

"……even the supports given inform of seeds and pesticides are not for free, the farmers pay for the inputs even at a later stage after harvesting their cotton. This can be by selling your cotton cheaply to the company that provided the inputs," (said the key informant, 2024).

The results show that most cotton farmers (68%) lacked community social factors that facilitate their capacity to adapt to climate change. The results reveal that most cotton farmers (51%) reported the presence of some factors that hindered their ability to adapt to climate change increasing their vulnerability.

The attributes that influence the vulnerability of smallholder cotton farmers to climate change are further presented in Table 6.

Table 6: Factors Influencing Vulnerability of Smallholder Cotton Farmers to Climate Change

Variables		Frequency	Percentage
Major Challenges Faced	Economic	110	59
	Health	43	23
	Environmental	35	19
Impact of Challenges	No	55	29
on the Community	**Yes**	**133**	**71**
Faced Economic	No	30	16
Hardships	Yes	**158**	**84**
Limited access to	No	**139**	**74**
financial resources	Yes	49	26
Support from	No	76	40
Government & Other Stakeholders	Yes	112	60
Type of support	Financial support	49	30
obtained	**Training and education**	**67**	**42**
	Access to climate information	20	13
	Agricultural inputs	24	15
Influence of Agricultural	No influence	59	31
Extension services	Slight influence	55	29
	Moderate influence	47	25
	Strong influence	9	5
	Very strong influence	18	10
Availability of	No	128	68
Community social factors	Yes	60	32
Hinderances	No	93	49
	Yes	95	51

Basing on table 7 (page 37) below, the three sub-counties have a varying level of exposure, adaptive capacities and Socio-economic factors determining their level of vulnerability. From the above, Lagoro with 0.8 is more exposed to the impact of climate change followed by Omiya-Anyima at 0.6 and Kitgum Matidi at 0.525. On the adaptive capacity, Lagoro has a very low capacity of 0.2, followed by 0.25 Kitgum Matidi and Omiya-Anyima with 0.4. This was equally revealed and confirmed during a focus group discussion by a participant who said;

> *"……. farmers in Sub-counties have been able to cope with the changing climate by alternating their growing season with the nature of the soil" (Said a participant in FGD 2024)*

The above information was further emphasized by a key informant who explained why some farmers are more vulnerable than others. The key informant said: -

> *"…. some farmers plant their cotton depending on the nature of the soil, for example, they grow cotton on sandy soils between April- May while on loam or muddy soil, they plant cotton around June, July or August" (Said a key informant 2024)*

Furthermore, Lagoro has major Socio-economic factors limiting their adaptive capacities and increasing their vulnerability with 0.45, followed by Omiya-Anyima at 0.425 and the least is Kitgum-Matidi with 0.25.

This study therefore revealed that smallholder cotton farmers in Lagoro are more vulnerable due to their high level of exposure, low adaptive capacity and their level of vulnerability is at 1.45, followed by Omiya-Anyima at 1.425 and Kitgum-Matidi with a low level of vulnerability at 1.025.

Table 7: Composite vulnerability index table

Indicator	**Exposure**			**Adaptive capacity**			**Socio-economic**		
Variables	Prolonged drought	Frequency of flood	Unpredictable rainfall	Health status	Access to finance	Access to information	Income level	Educ level	Social support
Score	L=2 K=1 O=2	3 2 2	4 3 3	1 1 2	1 1 1	1 1 2	1 1 1	2 1 2	2 1 2
Normalized score	L=0.5 K=0.25 O=0.5	0.75 0.5 0.5	1.0 0.75 0.75	0.25 0.25 0.5	0.25 0.25 0.25	0.25 0.25 0.5	0.25 0.25 0.25	0.5 0.25 0.5	0.5 0.25 0.5
Weight	L=0.2 K=0.3 O=0.3	0.4 0.3 0.3	0.4 0.4 0.4	0.2 0.2 0.2	0.2 0.4 0.4	0.4 0.4 0.4	0.2 0.5 0.3	0.4 0.3 0.4	0.4 0.2 0.3
Weighted score	L=0.1 K=0.075 O=0.15	0.3 0.15 0.15	0.4 0.3 0.3	0.05 0.05 0.1	0.05 0.1 0.1	0.1 0.1 0.2	0.05 0.125 0.075	0.2 0.075 0.2	0.2 0.05 0.15
Total	L=0.1+0.3+0.4= 0.8 K=0.075+0.15+0.3= 0.525 O=0.15+0.15+0.3= 0.6			L=0.05+0.05+0.1= 0.2 K=0.05+0.1+0.1= 0.25 O=0.1+0.1+0.2= 0.4			L=0.05+0.2+0.2= 0.45 K=0.125+0.075+0.05= 0.25 O=0.075+0.2+0.15= 0.425		
Vulnerability level	L= 0.8+0.2+0.45 = 1.45 K= 0.525+0.25+0.25 = 1.025 O= 0.6+0.4+0.425 = 1.425								

L= Lagoro, K=Kitgum-Matidi, O= Omiya Anyima.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Smallholder Cotton Farmers' Perceptions of Climate Change Risks and Weather Changes

Climate change plays a significant role in influencing the productivity of agro ecological systems and, hence, the food systems of any nation. This study aimed to assess the smallholder cotton farmers' perception on climate change in Kitgum district. The findings of this study are discussed below.

The observation that the majority of farmers noticed shifts in climate patterns like prolonged droughts, erratic rainfall, and temperature extremes, among others, can be linked to smallholder cotton farmers' reliance on rain-fed agriculture. This enables them to easily identify or notice even very small climate variability. These findings align with those by (Nyang'au et al., 2021), who revealed that most smallholder farmers in Kenya perceived changes such as reduced rainfall and temperatures as climate change. Similarly, (Nyberg et al., 2021) and (Rapholo & Diko Makia, 2020) noted in their study that most smallholder farmers reported having experienced climate change impacts, including but not limited to unpredictable weather and extreme events. The high awareness of ongoing climate change among smallholder farmers, therefore, lays a foundation for promoting localized climate adaptation programs.

Additionally, drought was a major climate change extreme experienced by smallholder cotton farmers can be associated with the drought's potential to not only disrupt cotton planting cycles but also reduce soil moisture and increase pests and disease outbreaks. This resultantly leads to a reduction in cotton yields and hence income earnings from cotton farming activities. A study by (Dissa et al., 2024) also revealed that droughts increase stress levels within plants due to water scarcity and increased pest infestations. This implies that to enhance the resilience of smallholder cotton farmers, it's imperative for government and other actors within the cotton value chains to prioritize investments in irrigation systems and infrastructure, as well as develop improved drought and pest and disease-resistant cotton varieties.

The findings reveal that most smallholder cotton farmers were concerned about climate change associated with the threats that climate change poses to their livelihoods, income, and

health. This concern is supported by the observation that the majority of smallholder cotton farmers reported that the climate changes had very severe effects on cotton farming activities, especially a reduction in cotton yields (Table 3). This concern is evidenced by the observations that most farmers experienced very severe impacts of climate change, especially a reduction in cotton yields and income earnings from cotton farming. This is because climate change is associated with extreme (high) temperatures and heat waves. This exacerbates the already existent vulnerabilities of smallholder cotton farmers like reliance on rain-fed cotton farming, low soil fertility, and hence reliance on synthetic agro-inputs, precisely fertilizers and pesticides.

In the same vein, the high concern among smallholder cotton farmers about climate change experienced can be linked to the fact that most of them reported that the climate changes experienced affected their cotton crops. This could be because cotton, as a crop, is very sensitive to temperatures and humidity. An advisory by the (National Cotton Council of America, 2025) also indicates that high temperatures or heat waves led to a decline in cotton yields among farmers in Kenya. Additionally, these findings are similar to those by (Khalid et al., 2025), who revealed that smallholder farmers were worried about a loss in incomes and food due to insecurity. This implies that key stakeholders who are advancing climate change mitigation and adaptation strategies should translate this concern to advance adaptation and mitigation efforts.

Similarly, smallholder cotton farmers operate in climate-sensitive agricultural systems where weather variability directly affects crop productivity and livelihoods. The finding that a high proportion of smallholder cotton farmers noticed weather changes can be attributed to increased awareness among these farmers about the sensitivity of cotton farming to weather and, hence, climate variations. This can partly be associated with the fact that the widely grown cotton variety - Gossypium spp (Upland cotton) has predefined growth requirements that are highly vulnerable to changes in temperature, precipitation, and extreme weather events (Khalid et al., 2025b). Additionally, given that cotton farming is often conducted for income, smallholder cotton farmers' daily interactions with their environment, together with the awareness of seasonality of cotton farming, could have made them more observant of climatic anomalies with the potential to affect planting schedules, pest dynamics, and harvest outcomes.

These findings are synonymous with those by (Getachew et al., 2025; Mubiru et al., 2018), whose studies revealed that significant proportions of farmers noticed significant changes in weather patterns. This implies that smallholder cotton farmers can play a pivotal role in monitoring changes in weather patterns in their areas. This heightened level of awareness can be leveraged to foster the integration of indigenous knowledge systems into climate change mitigation efforts.

The finding that most smallholder cotton farmers noticed climate can be linked to direct dependence on rain fed agricultural practices, and daily interaction with environmental conditions in their area. Additionally, cotton, being too sensitive to climatic variations, could have made farmers pay attention to even subtle shifts in weather patterns (Solidaridad, 2023). The increased awareness among smallholder cotton farmers about the weather changes can also be linked to the ubiquitous increase in the frequency and severity of weather events. These findings align with findings by (Mubiru et al., 2018) and (Tukezibwa, 2010), who reported that a significant proportion of smallholder farmers observed increased changes in weather patterns. These findings imply that smallholder cotton farmers not only have the potential to act as climate change observers in their areas but also play a critical role in the integration of indigenous knowledge systems and farmer observations into meteorological data.

Most smallholder cotton farmers noted unpredictable rainfall as a major change associated with the weather in their area can be linked to the fact that increased unpredictability of rainfall, including but not limited to the timing, intensity, and distribution, among others, directly affects all cotton growth stages. This is because for it to perform well, cotton plants require approximately 500 -1500mm of annual rainfall optimally distributed through the growing season (Singh et al., 2025). These findings align with observations by (Nyang'au et al., 2021) and (Nyberg et al., 2021), who reported poor rainfall distribution as a major challenge faced by smallholder farmers in Kenya. Studies by (Ogunbode et al., 2025) and (Ayanlade et al., 2017) also reported unreliable rainfall patterns in Nigeria. Such rainfall unpredictability disrupts both planting schedules and crop management practices of smallholder cotton farmers. This therefore calls for timely investment in irrigation and water harvesting systems, as well as development and distribution of improved weather-resistant cotton varieties.

The finding that most smallholder cotton farmers noticed changes weather every two years is an indication that they are experiencing climate variability instead of long-term climatic changes. This aligns with the increasing frequency of extreme weather events that are occurring across the globe.

These findings are similar to those by (Kone et al., 2022), who reported that smallholder cotton farmers perceived and noticed fluctuations in rainfall patterns in their areas. A study by (Getachew et al., 2025) also added that smallholder farmers in Ethiopia reported more frequent variations in climate change in their area. This directly translates to climate variability. These findings, therefore, are a sign that smallholder cotton farmers are most likely to find it challenging to operate within their conventional farming calendars and practices. Given that such variability may lead to maladaptation due to misperceptions, there is a need for continuous monitoring of these changes in weather patterns rather than establishing adaptation initiatives based on one-time monitoring data.

The finding that an overwhelming proportion of smallholder cotton farmers recognized a reduction in cotton yields and incomes as a major impact of climate change can be explained by the high sensitivity of cotton to climate variability and changes. Weather specifically affects the quantity of cotton yields, fiber content and quality, pest pressures, and input requirements across the growing cycle. These findings are similar to those by (Cetin & Basbag, 2010) and (Darawsheh et al., 2022), who reported that weather changes, especially drought, reduced the yields and fiber quality of cotton. The reduction in smallholder cotton farmers' yields can also be explained by the fact that heavy rains during harvest cause lint staining of cotton fiber, mold growth, and significant cotton fiber losses. This is supported by a study by (Heimoana, 2016) and the (National Cotton Council of America, 2025), who reported that extreme rains during cotton harvesting season cause lint staining, mold, and fiber strength loss. Such significant losses not only threaten smallholder cotton farmers' livelihoods but also reduce the cotton quality and increase smallholder cotton farmers' production costs.

5.2 Factors Influencing Smallholder Cotton Farmers' Vulnerability to Climate Change

The study found out that economic challenges were a major factor increasing the vulnerability of smallholder cotton farmers to climate change can be explained by the fact that smallholder cotton farmers operate with limited financial resources. This makes them highly sensitive to climate shocks. This can also be attributed to systemic challenges like

inflation in input costs and low bargaining power in markets that leave smallholder cotton farmers trapped in debt cycles (Ramatshekgisa & Naidoo, 2024). Additionally, economic instability restricts smallholder cotton farmers' ability to invest in climate-resilient inputs like drought-resistant seeds, irrigation systems, and or diversify livelihoods. Additionally, economic challenges could have influenced smallholder cotton farmers' vulnerability to climate change is due to the fact that cotton farming is a capital-intensive and price-volatile activity. This exacerbates climate risks, especially when yields drop due to extreme weather events. This is synonymous with findings by Nyberg et al. (2021), who reported that poverty and market fluctuations induced economic challenges amplify smallholder farmers' vulnerability to climate change. This means that interventions such as subsidies and insurance schemes that prioritize economic empowerment ought to reduce dependency on volatile cotton markets but promote investments in adaptation(Ojo et al., 2024).

Furthermore, the reflections reveal that a significant proportion of smallholder cotton farmers reported economic hardships can be linked to climate-induced income losses that limit their ability to meet basic needs such as food and healthcare. Economic troubles can also be linked to persistent structural poverty, a lack of savings, and insufficient social safety nets. These findings are consistent with those of Chepkoech et al. (2020) and a report by Tinsley and Agapitova (2018), which found that smallholder vulnerability is linked to limited access to non-farm income. Smallholder cotton growers should diversify through agroforestry and livestock integration to protect their households from climate shocks.

The discovery that a considerable proportion of smallholder cotton farmers lacked access to loans and savings for climate adaptation can be attributed to the fact that formal financial institutions frequently exclude smallholder cotton farmers from financial products.

This is due to collateral requirements and perceived risks associated with the different loan products. Informal loans, on the other hand, have high interest which only worsen smallholder cotton farmers' indebtedness. These results align with those by Tinsley & Agapitova (2018), who adduce that access to microfinance improves the adaptive capacity and climate resilience among rice farmers.

These findings are an indication that without credit, farmers cannot adopt technologies like drip irrigation, weather and disease-resistant seed varieties.

The findings that extension services did not significantly influence the adaptation of most farmers could be explained by the fact that extension agricultural programs accessed by smallholder cotton farmers could be poorly tailored, presented, and inaccessible. This is a common occurrence in areas where extension officers are overburdened and the top-down approaches are ineffective. These findings align with those by Jamil et al. (2023) and Alam et al. (2024), who revealed that the impact of extension is determined by the level of engagement with farmers and the rate at which localized content is presented. This implies decentralized extension systems that leverage digital tools and actively involve farmers in co-designing solutions.

The study revealed that most smallholder cotton farmers lacked community social factors such as cooperatives and trust networks to facilitate adaptation can be linked to the fragmented nature in which smallholder cotton farmers are distributed. As a result, such communities often face difficulties mobilizing resources. On the other hand, access to community social institutions leads to social cohesion that enables collective action during crisis handling. Akinola et al. (2023) also revealed in their study that cooperative and social group membership enhanced the resilience of smallholder farmers to climate change. This implies that to enhance the resilience of smallholder cotton farmers to climate shocks, it is imperative to strengthen community institutions, including farmer groups, to foster resource-sharing and collective bargaining.

Most smallholder farmers cited the presence of barriers that hindered their capacity to adapt to climatic extremes and associated risks can be attributed to institutional neglect, land tenure systems, and associated insecurity, as well as high levels of poverty. These factors significantly restrict the adaptive capacity of smallholder cotton farmers. This is similar to findings by Mwesigye & Barungi (2021) and Schürmann et al. (2020), who adduce that structural barrier like land fragmentation, lack of policy enforcement, and gender insecure land tenure systems often discourage farmers from investing in long-term soil conservation and regenerative practices. This calls for targeted policy reforms, especially land tenure and rights, and the establishment of gender-inclusive programs to address systemic inequities.

5.3 Smallholder Cotton Farmers' Adaptation Strategies

Climate adaptation is vital for ensuring the resilience of smallholder farmers to climate change shocks and extremes. This study aims to understand the different adaptation strategies

used by smallholder cotton farmers to mitigate climate extremes. These findings are discussed below.

To begin with, findings that most smallholder cotton farmers embraced drought-resistant cotton seed varieties can be associated with increased aridity and the prevalence of erratic rainfall patterns in this region. This is in direct response to the observation that drought was a major climate change noticed by smallholder cotton farmers. Drought-resistant cotton varieties are especially important in that they offer a practical solution to climate extremes by ensuring that the cotton crops grown are able to survive under adverse heat and water stress. However, it is important to note that the rate of adoption of these drought-resistant seed varieties is below average, that is, less than 50% due to limited access to these improved drought and pest-resistant seeds, high costs of accessing, and lack of awareness.

The lower rate of adoption of drought-resistant cotton varieties can also be associated with existing challenges in seed distribution and farmers' distrust of new technologies. Additionally, smallholder cotton farmers may prioritize traditional seeds due to reservations about yield quality, compatibility with local ecosystems, and insufficient extension support to facilitate the adoption of improved drought-resistant cotton seed varieties. These findings are corroborated by a study by (Jena et al., 2023), who reported that smallholder cotton farmers adopted drought-tolerant seeds for their cotton farming activities. (Kangogo et al., 2021) also noted that there's an increasing rate of adoption of climate-resilient cotton varieties by smallholder farmers. These, however, were either supported by their governments or farmer-led cooperative unions. This implies that there's an urgent need to prioritize input subsidization, especially the cost of breeding and accessing drought-resistant cotton seeds. Farmer field schools' led demonstrations should also be prioritized to facilitate evidence-based adoption of drought-resistant varieties.

The result that an overwhelming proportion of farmers expressed the need for financial assistance can be linked to the structural barriers that hinder climate adaptation. This is evidenced in the result that most smallholder cotton farmers not only faced economic hardships but also did not have access to financial resources. (Nakawuka et al., 2018) also note that smallholder cotton farmers often lack savings, credit access to invest in adaptation technologies like irrigation systems and improve seed varieties. Such financial constraints force farmers to rely on low-cost strategies, despite their inefficiencies. Therefore, smallholder cotton farmers' vulnerability to climate extremes and their ability to adapt to

these shocks are linked to their access to financial resources. Strengthening microfinance credit facilities, climate risk insurance, and grants will foster the adaptive capacity of smallholder cotton farmers to climate change.

5.4 Conclusion

The study concludes that smallholder cotton farmers are vulnerable to the impacts of climate change due to high exposure to climate – related hazards and limited ability to adopt due to limited access to finances. In this study, smallholder cotton farmers are acutely aware of changing weather patterns, notably rainfall unpredictability, which they perceive as regularly impacting their farming operations. This can be indicative of high sensitivity of cotton to climate variability and the possible increase in the intensity of climate impacts on smallholder cotton farmers. Additionally, climate change is no longer a myth but a reality being experienced by smallholder farmers. These changes have compounding impacts on cotton farming activities, especially, reduction in cotton yields, income, and hence the onset of food insecurity. This implies that cotton farmers in this area are highly vulnerable to climate change.

The study also further concludes that farmers employ various adaptation strategies ,including changing planting dates. Whereas smallholder cotton farmers use drought-resistant seed varieties in response to climate change, economic challenges, and lack of access to financial resources remain major barriers to the use of these seed varieties.

Economic challenges are a major determinant of the vulnerability of smallholder cotton farmers to climate change. This is exacerbated by limited access to social and financial institutions and difunctional extension services.

Inconclusion, further studies are required to assess effectiveness of the adaptation strategies in reducing smallholder farmers vulnerability and the role climate information services in improving farmers preparedness, decision making, and resilience to climate change.

5.5 Recommendations

1. Promotion of climate – smart agricultural practices involving integrated approaches such as Adoption and promotion of regenerative agricultural practices, drought-resistant seeds, and irrigation farming are essential for increasing the resilience of smallholder cotton farmers to climate change.

2. Government agencies and extension workers should strengthen climate information services. Improve access to timely and reliable weather forecasts to help farmers make better decisions on planting dates, crop management and harvesting. These would help to ensure sustainable adoption.

3. It is critical that government and other actors in the cotton value chain prioritize financial inclusion, insurance, income diversification, strengthening social capital, and addressing structural challenges of land tenure systems among smallholder cotton farmers to enhance their resilience to climate change. Financial supports should be given to farmers through affordable credit, insurance schemes and savings groups to improve their ability to invest in adaptation measures.

4. Strengthen farmer organizations and cooperatives by promoting collective action through cotton farmers groups to improve access to markets, inputs, technologies and climate information.

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APPENDICES

Appendix: I: household structured Questionnaires

Dear respondent

This Research study is being conducted by Aneno Irene Apwoyochan, a student of Gulu University with Reg number: 23/U/0620/MAG /PS and Student number 2301000620 at the Faculty of Education and Humanities pursuing Masters of Arts in Geography of Gulu University. The research is on the impact of climate change on smallholder cotton farming: risks, adaptation and vulnerability in Kitgum District, Uganda.

This research is for study purpose only and every data collected during this research will be treated with utmost confidentiality. The data collected shall be anonymized making it impossible to trace back to an individual. Therefore, the respondent's privacy shall be highly protected in this research.

Thanks alot

Consent:

1. I accept to voluntarily participate in this study, the researcher has explained everything and I believe no harm is attached to answering the questions.
2. I Do not accept to voluntarily participate in this study, the researcher has explained everything and I believe no harm is attached to answering the questions.

Coordinates

X---------- Y----------

Sub-county ---------- Parish ----------

Section A: Socio-Demographic characteristics of smallholder cotton farmers.

1. Age: Below 20 years ☐ 21 – 30 years ☐ 31 – 40 years ☐ 41 – 50 years ☐ above 50 years ☐

2. Gender: Male ☐ Female ☐

3. Level of education:

No formal education ☐ Primary education ☐ Secondary education ☐

Tertiary education ☐ Other (please specify) ……

4. Years of experience in Cotton farming:

Less than 5 years ☐ 5 – 10 years ☐ 11 -15 years ☐ Above 15 years ☐

5. Household location or GPS coordinates.

Latitude……longitude…….

6. Which type of cotton have you been growing?

Gossypium hirsutum (upland cotton) ☐ Gossypium barbadense (Egyptian cotton) ☐

Hybrid Varieties ☐ All the above ☐ Don't know ☐

7. What is the total land acreage that you possess?

Less than 10 acres ☐ 15 -30 acres ☐ 40 -60 acres ☐ Above 60 acres ☐

8. How many acreages is used for cotton farming?

Less than 3 acres ☐ 3-5 acres ☐ 6-10 acres ☐ More than 10 acres ☐

9. What is the source of labor for tilling your cotton farm?

Family members ☐ Hired labor ☐ Animal power/Oxen ☐ Tractor ☐

All the above ☐

10. Do you have any other occupation other than cotton farming?

Yes ☐ No ☐

11. What is the average monthly income from other sources/occupation apart from cotton farming?

Less than 100,000 Ug shs ☐ Between 100,000-200,000 Ug shs ☐

Between 200,000-500,000 Ug shs ☐ Above 500,000 Ug shs ☐

12. Are you a member of any social/community self-help Organization?

Yes ☐ No ☐

13. If yes, which social /community self-help Organization?

……

14. Do you have any cotton farmers group in your area?

Yes ☐ No ☐

15. If yes, what is/are the name of the cotton farmers group? ……

16. Do you have any benefactor who sends some remittance/support to the family?

Yes ☐ No ☐

17. If yes, what is the family's relationship with the benefactor?

……

Section B: Objective 1: Perceived Climate Change-Related Risks

1. Have you noticed any changes in weather patterns in your area?

Yes ☐ No ☐

2. If yes, what changes have you observed? (Tick all that apply)

Unpredictable rainfall ☐ Prolonged droughts ☐

Increased frequency of floods ☐ Occurrence of storms ☐

Others (Please specify) …….

3. If no, how long have you been experiencing this same weather pattern?

Less than 4 years ☐ 4 - 8 years ☐ 8 – 10 years ☐ more than 10 years ☐

4. How frequent have these changes been occurring?

Every year ☐ After every 2 years ☐ After 5 years ☐ After 10 years ☐

5. Do you think there has been changes generally in climate in the last 20 years?

Yes ☐ No ☐

6. How concerned are you about climate change?

Concerned ☐ Not concern ☐ Very concern ☐ Just little concern ☐

7. What do you think causes this change in climate?

……

8. Does these changes in weather pattern in question 2 above have any impact on your cotton farming activities? Yes ☐ No ☐

9. If yes, how have you been impacted by these changes as a cotton farmer?

……

……

10. How severe do you perceive the impact of climate change on your cotton farming activities?

Not severe ☐ Moderately severe ☐ Very severe ☐ extremely severe ☐

11. Does climate change (of any form) affect the cotton crop?

Yes ☐ No ☐

12. If yes, explain how the cotton crop is affected during the growing period?

……

……

13. In your opinion, what is the most significant climate change-related risk to your cotton farming?

Increased temperature ☐ Decreased rainfall ☐

Prolonged drought ☐ Pests and diseases ☐

Others (please specify) ……. …..

Objective 2: The adaptive capacities and coping mechanisms employed by smallholder cotton farmers to mitigate the effects of climate change in Kitgum District

1. Have you experience any significant changes related to climate?

Yes ☐ No ☐

2. If yes, could you describe the significant changes related to climate?

……

3. How often do you experience crop failure or reduced yield due to climate-related factors?

Never ☐ Rarely (once every 5 – 10years) ☐ Occasionally (once every 2 -4 years) ☐

Frequently (once a year) ☐ Always (every season) ☐

4. How was your cotton crop severely affected by climate-related factors?

Poor quality ☐ Reduced Yields ☐ Crop Loss ☐ Others (Specify)……

5. How does climate change affect your income from cotton farming?

No effect ☐ Slightly reduces ☐ Moderately reduces income s ☐

Significantly reduces income ☐ Severely reduces income ☐

6. How does these effects of climate change affect the family livelihood?

Debt ☐ Food insecurity ☐ Poor health ☐ School dropout ☐

Others (Specify)……

7. How do you cope with stress or emotional difficulties caused by the challenges you face?

……

……

8. What measures do you currently have in place to mitigate the effects of climate change on your cotton farming? (Select all that apply)

Irrigation ☐ Use of drought-resistant seeds ☐ Crop rotation ☐

Diversification of crops ☐ All the above ☐ Other (please specify) ……

9. How adequate are these measures in reducing your vulnerability to climate change?

Not adequate ☐ Slightly adequate ☐ Moderately adequate ☐

Very adequate ☐ Extremely adequate ☐

10. Is there any indigenous knowledge used by you/farmers to manage climate change related risk?

Yes ☐ No ☐

11. If yes, what are some of the indigenous knowledge used by you/cotton farmers to manage climate change related risk?.....

12. What additional support or resources would help you cope better in future?

Training ☐ Financial assistance ☐ Infrastructure improvement ☐

Others…….

13. What long term changes do you think will help you or your community become more resilient to future challenges?.....

14. Are there any specific areas where you feel vulnerable or unprepared for future climate change

challenges?.....

Objective 3: The factors influencing vulnerability of smallholder cotton farmers to climate change in Kitgum District.

1. What are the biggest challenges you have faced in recent years?

Economic☐ Health☐ Environmental☐ Others (specify)…….

2. Have these changes impacted you or your community?

Yes ☐ No ☐

3. If yes, could you describe them?.....

4. In the past year, have you faced economic hardships that affected your ability to meet basic needs?

Yes ☐ No ☐

5. What financial challenges do you face most frequently?

Unpredictable income ☐ Rising cost of living☐ Debt ☐ Low wages☐

Others (specify)……

6. Do you have access to financial resources (e.g., loans, savings) to invest in climate adaptation measures? Yes ☐ No☐

7. Have you received any support from the government, NGOs, or other organizations to help you deal with climate change?

Yes ☐ No ☐

8. What type of support do you receive for climate change adaptation? (Select all that apply)

Financial support☐ Training and education☐Access to climate information☐

Agricultural inputs (e.g. seeds, fertilizers) ☐None

Other (please specify)……

9. How does access to agricultural extension services influence your ability to adapt to climate change? No influence ☐ Slight influence ☐ Moderate influence ☐

Strong influence ☐ Very strong influence☐

10. Are there any community or social factors that help you to adapt to climate change?

Yes ☐ No ☐

11.If yes, what is/are some of the community/social factors that help you adapt to climate change?

……

12. Are there some factors that hinder your ability to adapt to climate change?

Yes ☐ No ☐

13. If yes, what are some of the factors that hinder your ability to adapt to climate change?

……..

14. Do you have any additional comments or suggestions on how to better manage climate change-related risks in cotton farming?

……

……

Thank you for the response and your time.

Appendix II: Focus Group Discussion Guide

Dear Respondent,

This Research study is being conducted by Aneno Irene Apwoyochan, a student of Gulu University with Reg Number: 23/U/0620/MAG /PS and Student Number 2301000620 at the Faculty of Education and Humanities pursuing Masters of Arts in Geography of Gulu University. The research is on the impact of climate change on smallholder cotton farming: risks, adaptation and vulnerability in Kitgum District, Uganda.

Therefore, I kindly request you to respond to spare some time and answer the following questions in order to obtain the findings.

Your response will only be used for academic purposes and they will be treated with Confidentiality.

Thank you.

Consent

Participants Sign **Sub-County**

1……. ……

2…… ……..

3……. ……..

4…… ……

5…… ……

Objective 1. Smallholder cotton farmers perceived climate change related risk

1. What is your experience in cotton farming?
2. What is your planting schedule, and how do you determine the timing?
3. How do climate conditions impact your cotton farming?
4. At what stage is cotton crop severely affected by climate change?
4. Have you faced any water scarcity issues?
5. What irrigation methods do you use, and how effective are they?
6. What are the main pests and diseases affecting your cotton crops?

Objective 2: The adaptive capacities and coping mechanisms employed by smallholder cotton farmers to mitigate the effects of climate change in Kitgum District

7. What adaptations have you made to cope with environmental changes?
8. Where do you get information about cotton farming?
9. How do you source seeds, fertilizers, and pesticides? Are there any challenges?
10. Have you encountered issues with the quality of inputs?

11. How do you handle the harvesting process? Are there any tools or machines you use?
12. What other crops do you grow alongside cotton?
13. Have you received any support from government programs or NGOs?
14. What types of support would be most beneficial to you?
15. Have you participated in any training programs? What topics were covered?
16. What kind of training do you feel would be most beneficial?
17. Are there local farmer groups or cooperatives you belong to?
18. How do these groups support you in your farming activities?

Objective 3: The factors influencing vulnerability of smallholder cotton farmers to climate change in Kitgum District

19. What are the main challenges affecting your cotton farming?
20. How do you manage these challenges?
21. How do you sell your cotton?
22. What challenges do you face in accessing markets?
23. What are your biggest financial challenges in cotton farming?
24. Are you able to access credit or financial assistance?
25. Are you interested in adopting more sustainable farming practices? What would that look like for you?
26. What new technologies or practices are you interested in exploring
27. What role do you see for farmers in addressing community issues?
28. How do you think your farming practices affect your community
29. What was the most surprising thing you learned during this discussion?
30. Do you have any questions regarding our discussion?

Thank You for the Response and Your Time.

Appendix III: Interview Guide for key Informants

Dear respondent,

This Research study is being conducted by Aneno Irene Apwoyochan, a student of Gulu University with Reg Number: 23/U/0620/MAG /PS and Student Number 2301000620 at the Faculty of Education and Humanities pursuing Masters of Arts in Geography of Gulu University. The research is on the impact of climate change on smallholder cotton farming: risks, adaptation and vulnerability in Kitgum District, Uganda.

Therefore, I kindly request you to respond to spare some time and answer the following questions in order to obtain the findings.

Your response will only be used for academic purposes and they will be treated with Confidentiality.

Thank you.

Consent

Position……organization……

Objective 1: Smallholder cotton farmers' perceived climate change-related risks

1. How long have you been engaged with cotton farmers in this area?
2. In your experience, have you noticed any changes in the climate over the past few years?

[If yes] What specific changes have you observed?

3. What is the most significant climate-related challenges faced by cotton farmers in recent years?

(Issues like increased temperatures, change in rainfall patterns, droughts, floods, or pest infestations.

How do you think these climate change have affected cotton farming activities in this area?

4. Have these challenges affected your decisions as stake holders in cotton production?

If so how?

5. What changes do you anticipate in the next decade related to climate change?

Objective 2: The adaptive capacities and coping mechanisms employed by smallholder cotton farmers to mitigate the effects of climate change in Kitgum District

6. How are these cotton farmers adapting to the climate change related risk?
7. What role do you play to help the cotton farmers manage these challenges from climate change?

8. What support or resources does your office/organization/ company or government give to the cotton farmers in this area and how effective are these support in reducing the negative impact of climate change on the cotton farmers?

9. Are you aware of any government policies that impact cotton farming?

If yes, what are some of these policies?

10. How do these policies impact cotton farming?

Objective 3. The factors influencing smallholder cotton farmer's vulnerability to climate change

11. What factors do you think make some cotton farmers more vulnerable to climate change related risk than others?

12. Do you think the livelihood of these smallholder cotton farmers will be better or improved in the future?

13. What do you think should the cotton farmers do to improve their livelihood?

14. What do you believe are the key steps needed to mitigate climate change impacts effectively?

15. How can different sectors (government, private, non-profit Organization) work together to combat climate change?

16. Do you have any additional comments or suggestions on how to better manage climate change-related risks in cotton farming?

Thank You for the Response and Your Time.

Appendix IV: Introductory Letter

GULU UNIVERSITY

P.O. BOX 166 GULU

TEL: +256471432922;

OFFICE OF THE DEAN, FACULTY OF EDUCATION AND HUMANITIES

October 14, 2024

TO : WHOM IT MAY CONCERN

This is to introduce to you Ms. Aneno Irene Apwoybchan (Reg No. 23/U/0620/MAG/PS) a student pursuing a programme of study leading to an award Master of Geography of Gulu University, Master of Gulu University.

She is undertaking research on the Topic:

CLIMATE CHANGE IMPACTS ON SMALL HOLDER COTTON FARMING: RISKS, ADAPTATION, AND VULNERABILITY IN KTGUM DISTRICTS, UGANDA

Which is in partial fulfilment of the requirements for the award.

Any assistance rendered to her in relation to this research work will be highly appreciated.

Yours faithfully,

GULU UNIVERSITY
14 OCT 2024
FACULTY OF EDUCATION AND HUMANITIES

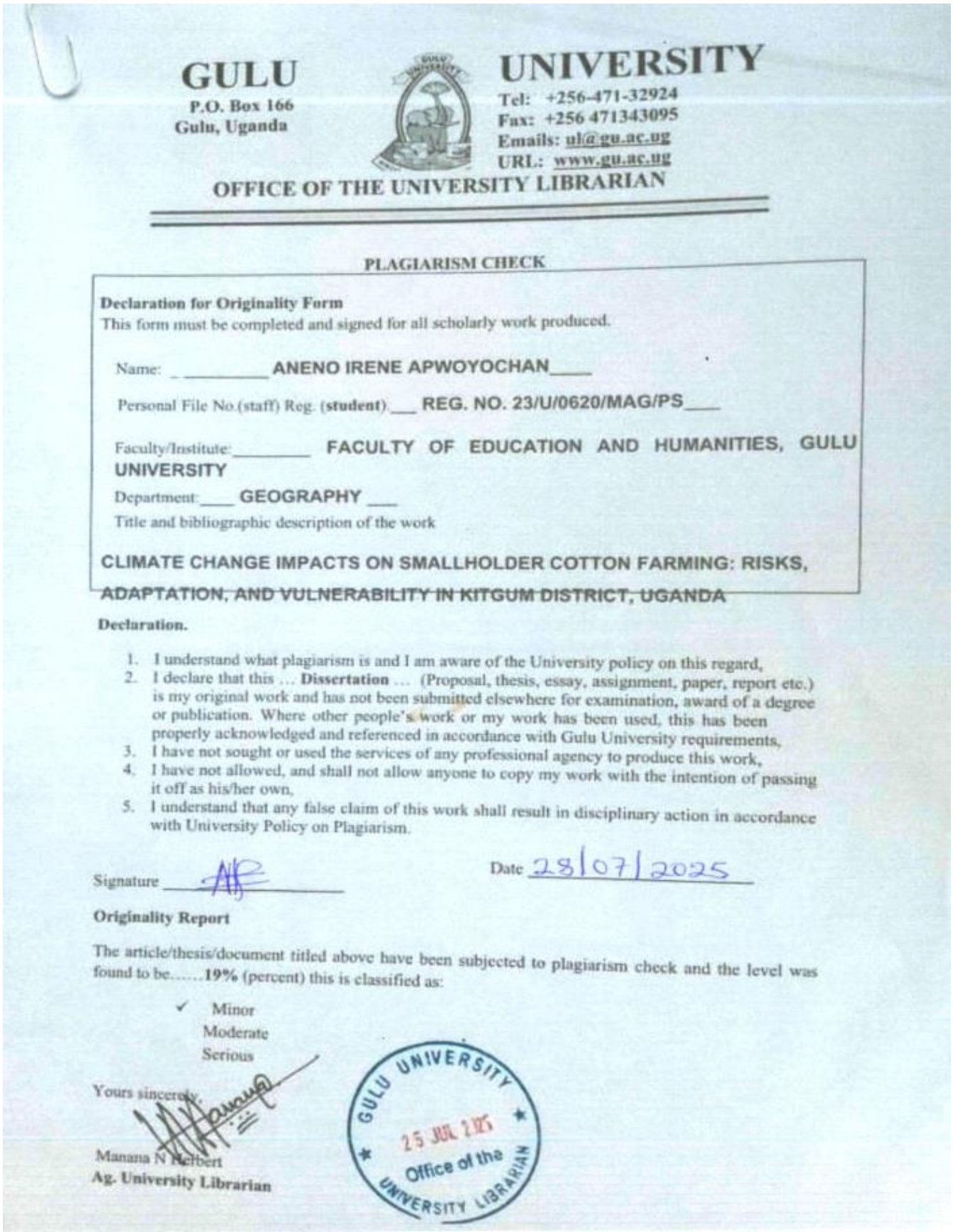
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Appendix V: Anti-Plagiarism Certificate



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PLAGIARISM CHECK

Declaration for Originality Form
This form must be completed and signed for all scholarly work produced.

Name: ANENO IRENE APWOYOCHAN

Personal File No.(staff) Reg. (**student**) REG. NO. 23/U/0620/MAG/PS

Faculty/Institute: FACULTY OF EDUCATION AND HUMANITIES, GULU UNIVERSITY

Department: GEOGRAPHY

Title and bibliographic description of the work

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Declaration.

1. I understand what plagiarism is and I am aware of the University policy on this regard,
2. I declare that this … **Dissertation** … (Proposal, thesis, essay, assignment, paper, report etc.) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my work has been used, this has been properly acknowledged and referenced in accordance with Gulu University requirements,
3. I have not sought or used the services of any professional agency to produce this work,
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own,
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Originality Report

The article/thesis/document titled above have been subjected to plagiarism check and the level was found to be……**19%** (percent) this is classified as:

✓ Minor
Moderate
Serious

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Ag. University Librarian

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GLOSSARY

- Drought -resistant crops: These are crops that can survive and produce yield with little water. They can be grown in areas which receive little rainfall.
- Integrated Approaches: These means combining different methods or ideas together to solve a problem. For example, in farming, combining modern technology, traditional knowledge and environmental care to mitigate the impact of climate change.
- Climate Change: This is a long-term change in the average weather patterns on the earth.
- C.D.O: Cotton Development Organization. It's a government agency in Uganda responsible for improving cotton industry. It promotes better cotton production practices by training the farmers.
- GADC: Gulu Agricultural Development Company. It's a private company in northern Uganda that works with farmers to improve agricultural production by supporting cash crop farming through training and input.
- N.G.O: Non-Governmental Organization. An independent organization that works to help people or community in areas like agriculture, environment and others.
- IPCC: inter-governmental panel on climate change
- EACUL: East Acholi Cooperative Union Limited. An agricultural cooperative founded in Kitum district to support cotton farmers across the East Acholi region specifically, to provide collective bargaining power.
- Crop diversification: This is the growing of different types of crops on a farm instead of just one. It helps to reduce risk, improves soil health and increase income.
- Erratic rainfall: This is when rain comes at unexpected times, in unusual amounts. It can lead to drought or flood making farming difficult.
- Temperature: This is how hot or cold something is. In farming, temperature affects how crops grow.
- FAO: Food and Agricultural Organization of the United Nations. It is a specialized agency of the United Nations established in 1945 with the mandate to promote sustainable agriculture, forestry, and fisheries.