

**AN ASSESSMENT OF METEOROLOGICAL DROUGHT AND ITS
EFFECTS ON MAIZE YIELDS IN PALABEK OGILI SUB COUNTY,
LAMWO DISTRICT**

BY

ACIRO FLORENCE

REG: 22/U/1528/MAG/PS

BAE.GU (2017)

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

NOVEMBER, 2025

DECLARATION

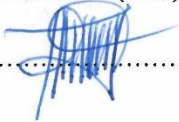
I **Aciro Florence** do declare that the work presented in this dissertation is my own original work with the topic, “An Assessment of Meteorological Drought and its effects on Maize Yields in Palabek Ogili Sub County, Lamwo district”. This work has never been submitted to any academic institution for an academic award.

Signature.......... Date ..10/11/2025..

APPROVAL

This dissertation entitled: “An Assessment of Drought and its effects on maize yields in Palabek Ogili Sub County, Lamwo district” has been written by Aciro Florence under my supervision and is now ready for submission with my approval.

Dr. Chombo Oketcho (PhD)

Signature..........Date.....10/11/25.....

Dr. Justine Kilama Luwa (PhD)

Signature..........Date.....10/11/2025.....

DEDICATION

This work is dedicated to the following people; my beloved son, Ladwar Maxwell McCaffrey, whose presence fills my life with joy and purpose, my dear daughter, Lamaro Venancy Precious, for being a constant source of inspiration, and my mother, Mrs. Sidonia Canagola, whose unwavering love, strength, and support have been a foundation for all my endeavors. Thank you for your endless encouragement and belief in me.

ACKNOWLEDGEMENT

I would like to express my heartfelt gratitude to my supervisors, Dr. Chombo Oketcho (PhD), Department of Geography, Faculty of Education and Humanities, and Dr. Justine Kilama Luwa (PhD), Department of Biology, Faculty of Science, for their invaluable guidance, support, and expertise throughout the course of this research. Their constructive feedback, insightful suggestions, and encouragement were instrumental in the completion of this study.

I also thank the other lecturers in the geography department, Dr Oriangi George, Dr Nuwategeka Expedito, Dr. Alule Jimmy Rhombe and Mr. Kisira Yeeko for the support they rendered to see me through this level of academic journey.

I am equally grateful to all the participants who took time off their busy schedules to share their knowledge and experiences, making this research possible. Their insights provided essential information for understanding the impact of drought on maize yields in Palabek-Ogili Sub County, Lamwo District.

Finally, I wish to acknowledge my colleagues and course mates for their support, encouragement, and constructive discussions that helped shape this research. Their camaraderie and intellectual contributions are greatly appreciated.

TABLE OF CONTENTS

DECLARATION	i
APPROVAL	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	x
ABSTRACT	xi
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background	1
1.2 Problem statement	3
1.3 General objective	4
1.3.1 Specific objectives	4
1.4 Research questions	4
1.5 Justifications of the study	4
1.6 Significance of the study	5
1.7 The scope of the study	6
1.8 Conceptual Framework	7
CHAPTER TWO	8
LITERATURE REVIEW	8
2.1 Historical patterns	8
2.2 The relationship between Drought and Maize Yields	9
2.3 Adaptation strategies by maize farmers to drought	11
CHAPTER THREE	13
METHODOLOGY	13
3.0 Introduction	13

3.1 Research Design.....	13
3.2 Study Area	13
3.2.1 Location	13
3.2.2 The vegetation.....	15
3.2.3 Climate.....	15
3.2.4 Main economic activities	15
3.2.5 Relief and topography	15
3.3 Study population	16
3.4 Sample size and procedure.....	16
3.4.1 Sample size	16
3.4.2 Sampling Procedure	17
3.5 Data Collection Methods and Instruments.....	18
3.5.1 Household Survey.....	18
3.5.2 Key Informant Interviews	18
3.5.3 Satellite Data Collection	18
3.6 Data Analysis	19
3.6.1 The Standardized Precipitation Index	19
3.6.2 Pearson’s correlation coefficient (r).....	20
3.6.3 Thematic analysis.....	21
3.6.4 Frequencies and percentages.....	21
3.7 Data Quality Management	21
3.7.1 Reliability.....	21
3.7.2 Data validity	22
3.8 Limitations and Delimitations.....	22
3.9 Ethical consideration.....	23
CHAPTER FOUR.....	24
PRESENTATION AND INTERPRETATION OF RESULTS.....	24
4.0 Introduction.....	24

4.1 The Historical Patterns of Drought in Palabek Ogili sub county, Lamwo district from 1980 to 2020	24
4.1.1 Severity of Drought.....	25
4.1.2 Duration of Drought.....	26
4.2 Relationship between drought and maize yields in Palabek Ogili sub county, Lamwo district	32
4.3 Adaptation Strategies of Maize Farmers in Palabek Ogili sub county, Lamwo district	40
CHAPTER FIVE	47
DISCUSSION OF FINDINGS	47
5.0 Introduction.....	47
5.1 The Historical Patterns of Drought from 1980 to 2020 in Palabek Ogili sub county, Lamwo district	47
5.2 The relationship between Drought and Maize Yields in Palabek Ogili sub county, Lamwo district	49
5.3 Adaptation strategies of maize farmers to drought in Palabek Ogili sub county, Lamwo district	52
CHAPTER SIX.....	59
CONCLUSION AND RECOMMENDATION.....	59
6.0 Introduction.....	59
6.1 Conclusions.....	59
6.1.1 Historical patterns of drought in Palabek Ogili Sub County, Lamwo district.....	59
6.1.2 Relationship between drought and maize yields in Palabek Ogili Sub County, Lamwo district	Error! Bookmark not defined.
6.1.3 Adaptation strategies of maize farmers to drought in Palabek Ogili sub county, Lamwo district	59
6.2 Recommendations.....	60
6.2.1 Historical Patterns of Drought in Palabek Ogili Sub-County, Lamwo District (1980–2020)	60
6.2.2 Relationship Between Drought and Maize Yields in Palabek Ogili Sub-County, Lamwo District	60

6.2.3 Adaptation Strategies of Maize Farmers to Drought in Palabek Ogili Sub-County, Lamwo District	61
6.2.4 Areas for further research	61
REFERENCES	64
APPENDICES	75
Appendix I: Questionnaire to Households	75
Appendix II: Interview Guide for Key Informant.....	80
Appendix III: Introductory Letter	83

LIST OF TABLES

Table 1: Parameters and values used for sample size calculation	17
Table 2: Proportionate sample size	17
Table 3: Standardized Precipitation Index (SPI)	20
Table 4: Thematic Analysis of Meteorological Drought in Palabek-Ogili Sub County (1980–2020)	28
Table 5: Correlations between drought and maize yields	32
Table 6: The coefficients	34
Table 7: Thematic Clustering of Responses on Impacts of Drought on Maize Yields.....	35
Table 8: The adaptation strategies adopted by maize farmers (n=302)	40
Table 9: Thematic Analysis of Adaptation Strategies of maize farmers to drought.....	41

LIST OF FIGURES

Figure 1: Conceptual Framework	7
Figure 2: Location of the study area	14
Figure 3: SPI01	24
Figure 4: SPI03	25

ABSTRACT

Globally, droughts have continued to be a major threat to agricultural production. This study examined the effects of meteorological drought on maize yields in Palabek Ogili Sub County, Lamwo District, with a focus on drought severity, intensity, and duration which affect output. By assessing historical climate data base alongside maize yield performance, the researcher seeks to identify the effects of drought on maize yields and offer insights into potential adaptation strategies to drought. A mixed-methods approach was adopted, combining quantitative data from 302 structured questionnaires and qualitative insights from key informant interviews. Quantitative data were analyzed using Standardized Precipitation index, Pearson's correlation coefficient and descriptive statistics. Whereas qualitative data were analyzed using Thematic analysis. The analysis revealed a strong positive correlation between drought severity and reduced maize yields ($r = 0.692$, $p = 0.01$), a moderate positive correlation for drought intensity ($r = 0.621$, $p = 0.01$), and a weaker but significant correlation for drought duration ($r = 0.366$, $p = 0.01$), indicating that all aspects of drought negatively affect maize productivity, with severity being the most influential. The qualitative analysis showed limited access to timely weather information, low use of modern adaptation techniques, and reliance on traditional adaptation strategies are the major challenges to adapting to drought. The study concludes that meteorological drought significantly reduces maize yields while farmer access to accurate climate data, drought-tolerant maize varieties, and farmer training improve on adaptation to drought. It recommends strengthening partnerships among farmers, meteorological services, and agricultural officers, as well as scaling up climate-smart agriculture to boost resilience and protect food security in Palabek Ogili sub county, Lamwo district.

CHAPTER ONE

INTRODUCTION

1.1 Background

Globally, droughts have continued to be a major threat to agricultural production and maize production in particular yet maize is such an important crop due to its widespread cultivation, nutritional value, and contribution to food security and livelihoods for millions of people around the world. These impacts are a result of water stress, reduced soil moisture availability, and altered physiological processes within the maize plants (Daryanto et al., 2016). Water stress caused by drought limits the availability of water for maize plants, leading to reduced growth and development. Insufficient water supply affects key physiological processes such as photosynthesis, nutrient uptake, and cell expansion, which are critical for optimal maize yield formation (Hochman et al., 2019).

Drought also affects maize yields during the reproductive stage, particularly during tasseling, which is the stage in maize reproduction when the silks, which are the fine, hair-like structures emerging from the ear (female flower), occur. Insufficient water availability at this crucial time can lead to reduced pollen viability, inadequate pollination, and poor grain (Daryanto et al., 2016). This results in reduced grain development and lower yield. Additionally, drought-induced water stress can cause premature leaf wilting in maize plants. This reduces the overall leaf area and limits the photosynthetic capacity of the plants, leading to decreased assimilation of carbon dioxide and energy for grain filling (Lesk et al., 2016).

Research in various regions has extensively recorded the direct consequences of drought on maize production. For instance, a study by Asseng et al., (2017), which encompassed maize-growing regions across the globe, underlined the considerable reduction in yields attributed to drought. Their findings revealed that losses in yield due to water limitations varied from 4% to 39%, contingent on the severity and duration of the drought events. Similarly, research conducted by Lobell et al. in 2018 estimated that drought-induced reductions in maize yields in the United States ranged from 9% to 27% across different states involved in maize production during the study period.

Throughout the African continent, drought occurrences have consistently been linked to significant decreases in maize yields. Specifically, the influence of drought on maize production in Sub-Saharan Africa has been well-documented, with substantial reductions in

yields, often ranging from 15% to 50%, contingent on the severity and duration of the drought events (Sehgal et al., 2018). In a regional study focused on Nigeria, the impact of drought stress on maize yields was examined, revealing reductions in the range of 28% to 35% during the crucial reproductive stage of the crop (Oguntunde et al., 2017). Similarly, Mugabe et al., (2020) conducted research in Zimbabwe, investigating the repercussions of drought on maize production. Their findings indicated that severe drought years led to yield reductions of up to 50%. These studies collectively emphasize the significant and far-reaching impact of drought on maize production across different regions in Africa.

Drought exerts various physiological effects on maize plants, leading to yield reductions. East Africa is susceptible to recurrent droughts due to its semi-arid and arid climatic conditions. According to Abara et al. (2020), drought-induced water stress leads to reduced soil moisture availability, inhibiting optimal growth and development of maize plants. Frequent dry spells during critical growth stages, such as flowering and grain filling, interrupt reproductive processes and diminish the formation of grain yield (Sehgal et al., 2018). East Africa's heavy reliance on rain fed agriculture exposes maize crops to greater vulnerability, as they are directly dependent on rainfall patterns (Gornall et al., 2017). Olatinwo et al., (2020) examined the physiological responses of maize to drought stress in Kenya and demonstrated that water stress significantly decreased leaf area, photosynthetic rate, and chlorophyll content, thereby impairing overall plant growth and productivity. Drought events in East Africa have resulted in substantial yield reductions and production losses in maize. Sehgal et al. (2018) conducted a comprehensive analysis of the effects of drought on maize yield across different agro-climatic zones in Sub-Saharan Africa, including East Africa. They reported yield losses ranging from 15% to 50% due to drought severity and duration.

Droughts in Uganda are becoming more frequent hence threatening maize production. Uganda has experienced twice as many droughts between 1970 and 2010 compared with earlier periods of 1920-1970. Adaptation strategies to droughts are higher in the southern part of Uganda than in the north. This means that farmers in northern Uganda are more vulnerable to drought than other parts of the country. It is therefore observed that maize yields in northern Uganda tend to record higher levels of vulnerability, exposure, and sensitivity due to its higher latitudinal location (GOU, 2012).

Palabek Ogili sub-county, located in Lamwo district, is an agricultural region that heavily relies on maize production. However, the region is prone to drought, which has a significant

impact on maize yields. Previous studies have shown that drought can reduce maize yields by up to 50%. In the context of Palabek Ogili Sub County, located in Lamwo district, Uganda, drought events have become increasingly frequent and severe in recent years (UNDP, 2020). This has raised concerns about their detrimental effects on crop production, particularly maize, which is a staple food and a critical source of livelihood for the local population (FAO, 2018).

1.2 Problem statement

Globally, drought is a major threat to maize production, with Asseng et al. (2017) reporting yield reductions ranging from 4% to 39% due to drought intensity and duration across various maize-growing regions. Similarly, Lobell et al. (2018) found that in the United States, drought-induced losses in maize yields ranged from 9% to 27% depending on regional exposure. In East Africa, Kiptum et al. (2020) highlighted drought as a critical stressor on maize farming, particularly in semi-arid areas with limited access to irrigation and climate services. In Uganda, drought events have become increasingly frequent and severe in recent years (UNDP, 2020). Ideally, farmers in maize-dependent regions like Palabek-Ogili Sub County in Lamwo District should be able to rely on stable rainfall patterns and accurate meteorological data to sustain consistent maize yields and ensure food security. However, the reality on the ground is far from this ideal, as long duration and increasingly severe drought have disrupted traditional farming cycles, leading to declining maize productivity. The primary causes of this challenge in Lamwo include erratic rainfall patterns, limited access to climate-smart technologies, poor dissemination of meteorological data, and overdependence on rain-fed agriculture. The effects are severe, including reduced household food availability, income loss, and increased vulnerability of smallholder farmers. Whereas there are some studies on the influence of drought on maize production in northern Uganda, particularly in Kitgum and Lamwo districts, these studies do not directly address the historical drought patterns. Studies such as those by FAO (2019) and Otim et al. (2018), have focused mainly on promoting drought adaptation strategies in northern Uganda. These efforts primarily targeted crops like millet, cassava, and sorghum, leaving a gap in localized research on maize. Moreover, these studies have not addressed the historical relationship between drought patterns and maize yield variability specifically in Palabek Ogili sub county, Lamwo District. This seems to leave a gap in knowledge regarding the effects of historical drought on maize production, given the importance of maize crop in the livelihood of the people of northern Uganda. This study therefore addressed the knowledge gap by systematically examining the historical patterns of

meteorological drought and its effects on maize yields in Palabek-Ogili Sub County, Lamwo district providing a basis for evidence-based adaptation strategies.

1.3 General objective

To improve the understanding of drought dynamics and how it affects maize yields in Palabek-Ogili Sub County, Lamwo district.

1.3.1 Specific objectives

- i. To determine the historical patterns of drought in Palabek-Ogili Sub County, Lamwo district from 1980 to 2020.
- ii. To investigate the relationship between meteorological drought and maize yields in Palabek-Ogili Sub County, Lamwo district.
- iii. To assess the adaptation strategies to drought used by maize farmers in Palabek-Ogili sub county, Lamwo district.

1.4 Research questions

- i. How have the severity, intensity and duration of drought events varied over time in Palabek-Ogili Sub County, Lamwo district from 1980 to 2020?
- ii. What is the relationship between metrological drought and maize yields in Palabek-Ogili Sub County, Lamwo district from 1980 to 2020?
- iii. What are the most and least used adaptation strategies to drought by maize farmers in Palabek-Ogili Sub County, Lamwo District?

1.5 Justifications of the study

The research aligns directly with the various United Nations Sustainable Development Goals (SDGs), including goal one which states that no poverty by 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round, goal two which states that zero hunger which aims to create a world free of hunger by 2030 by achieving food security, improved nutrition, and promoting sustainable agriculture, and goal thirteen which states that climate Action which aims at taking urgent action to combat climate change and its impacts.

The research also aligns with National Development Plans (NDPs). For example, economic transformation which typically highlights the country's economic development strategies,

policies, and priorities (GoU NPA, 2010). Assessing the impact of drought on maize yields is directly related to agricultural productivity, which is a key driver of economic growth and transformation in the country and agriculture and food security whereby this research addresses critical issues related to agriculture and food security, which are central themes in Uganda's development plans and resilience building (NDP II) whereby this study focused on adaptive strategies to cope with drought hence building resilience to climate change and natural disasters. (GoU NPA, 2017).

The research directly relates to Uganda Vision 2040 by addressing key challenges and opportunities in the agricultural sector, especially concerning agricultural productivity, technology adoption, value addition, livelihood improvement, and the empowerment of disadvantaged groups. The study has the potential to provide insights and recommendations that can contribute to the achievement of these goals outlined in the vision document

The study findings would also offer valuable insights for policymakers, governmental agencies, and NGOs working on agriculture, food security, and climate resilience in Uganda. This empirical evidence informs a basis for policy decisions related to drought preparedness, climate adaptation, and agricultural development.

1.6 Significance of the study

This study is significant on multiple levels. Locally, it benefits the community in Palabek-Ogili Sub County by offering evidence-based insights into effective drought adaptation strategies to enhance maize production resilience, ultimately improving the livelihoods of smallholder farmers. Nationally, the findings align with Uganda's development priorities, particularly in agriculture, economic transformation, and climate resilience, and may inform relevant policies and planning. Globally, the research contributes to the broader discourse on sustainable development by addressing critical challenges such as poverty, hunger, and climate change, in line with the United Nations Sustainable Development Goals (SDGs). Academically, the empirical data generated provides a foundation for further scholarly inquiry into the impacts of drought on agriculture, supporting ongoing research and knowledge building in climate-related agricultural studies.

1.7 The scope of the study

In terms of the time frame, the study focused on a comprehensive analysis of historical drought patterns, impacts on maize yield, and adaptation strategies of smallholders' farmers over a significant period from 1980 to 2020. This time frame was chosen to capture long-term trends in drought occurrences and their effects on maize yields, as well as to assess the evolution of adaptation strategies among farmers in Palabek-Ogili Sub County, Lamwo District. This 40-year period allowed for an in-depth examination of historical drought patterns, changes in maize yields, and the effectiveness of various adaptation measures over time. According to Kartal & Nones (2024), longer periods are recommended, especially when a study assesses the drought effects on socio-economic livelihoods such as agriculture and crop yield, since the effects of drought can manifest over the long term.

In spatial terms, the study was confined to Palabek-Ogili Sub County in Lamwo District, Northern Uganda. Palabek-Ogili was specifically selected due to its prominence as a maize-growing region and its notable vulnerability to drought events, as evidenced by historical climate data and consultations with local experts. This localized focus ensured that the findings were relevant to the specific environmental and socio-economic conditions of the area, allowing for targeted recommendations and interventions.

The content scope encompassed three main areas; historical patterns of drought which examined the severity, intensity, and duration of drought events in Palabek-Ogili Sub County over the selected timeframe. It included analyzing historical rainfall data, drought incidence records, and local perceptions of drought patterns. The second area was the effects of drought on maize yields: This dimension investigated how drought conditions affected maize yields, including reductions in yields, and the economic implications for local farmers. The study utilized both quantitative data from maize production records and qualitative data from farmer interviews and the third area was the adaptation strategies. This study assessed the various adaptation strategies employed by maize farmers to mitigate the effects of drought. It covered adaptation strategies such as the adoption of drought-resistant maize varieties, changes in farming practices, and community-based initiatives. The effectiveness and challenges of these strategies were explored through surveys and interviews with farmers and local agricultural officers.

1.8 Conceptual Framework

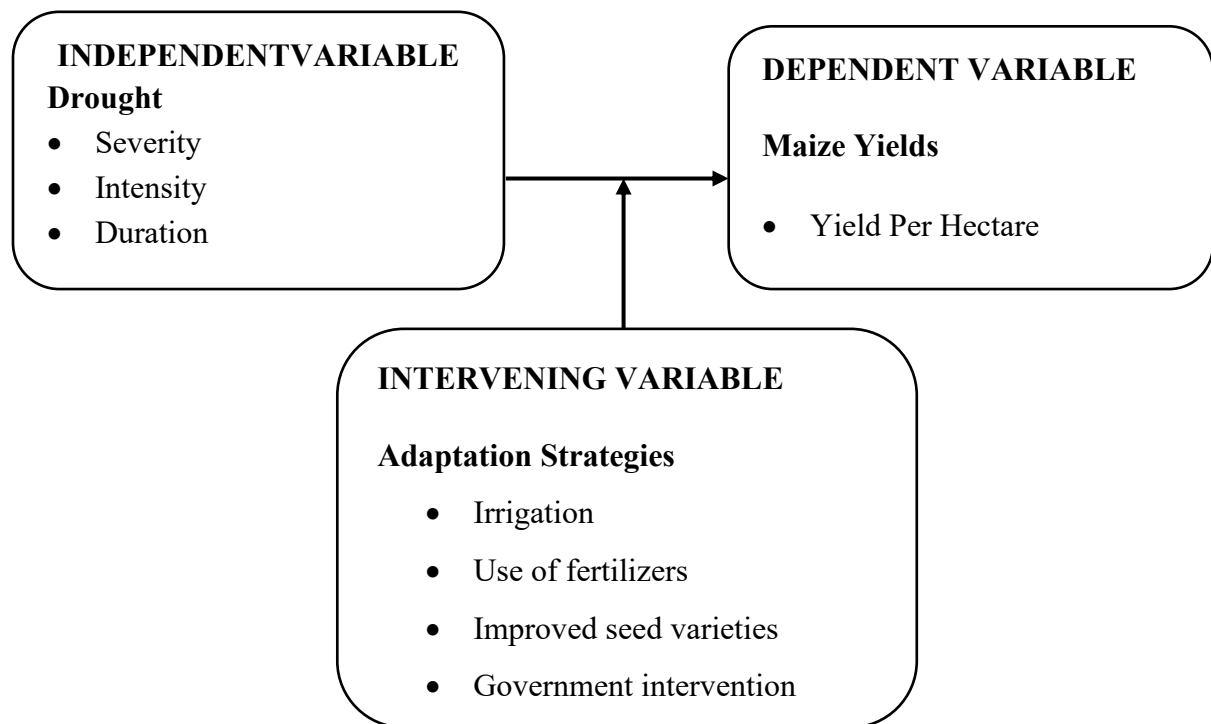


Figure 1: Conceptual Framework

The conceptual framework illustrates the relationship between drought (independent variable), maize yields (dependent variable), and adaptation strategies (intervening variable). Independent Variable in this study is meteorological drought which refers to precipitation deficit over a specific region compared to typical historical rainfall patterns which consequently leads to the hydrological drought which refers to prolonged shortage of water resources such as ground water, river flow and reservoir levels due to sustained reductions in precipitation and agricultural drought which is insufficient soil moisture to meet the needs of crops, leading to reduced agricultural drought (Tigkas et al., 2019). This was measured by examining three parameters namely; intensity, which is the severity of drought conditions and duration that is the length of time the drought lasts. The dependent variable is maize yields. This was measured in terms of kilograms of maize per hectare which are affected by drought. The intervening variable was adaptation strategies adopted by the farmers. Since the study targeted meteorological drought, whose consequences cut across hydrological and agricultural drought, the adaptation strategies were also an array of those targeting all droughts for instance irrigation, small scale watering, planting fast growing seeds, early planting among others for meteorological drought, water harvesting, channeling water into the garden among others for hydrological drought and mulching, planting cover crops, among others for agricultural drought.

CHAPTER TWO

LITRATURE REVIEW

2.1 Historical patterns

The phenomenon of climate change has given rise to an alarming increase in the frequency and severity of drought events globally (WMO, 2018). This escalating trend poses a significant threat to global agriculture, particularly maize production. These droughts, characterized by prolonged periods of inadequate rainfall and rising temperatures, have direct and indirect implications for maize yields. Drought-induced water stress, coupled with elevated temperatures, can significantly disrupt critical growth stages, reduce pollination rates, and impair overall plant development (Lesk et al., 2016).

Drought-induced physiological responses in maize plants further explains the mechanisms behind reduced yields. Boyer (1982) conducted a seminal study on the impact of drought stress on maize yield and photosynthesis. This research revealed that drought stress triggers a cascade of physiological responses, including reduced stomatal conductance, lower leaf water potential, and decreased photosynthetic rates. Such alterations significantly impede the plant's ability to convert solar energy into biomass, resulting in lower yields during drought conditions.

A comprehensive analysis of global maize production, utilization, and consumption (Shiferaw et al., 2011) underscores the paramount importance of maize as a staple crop, not only for food security but also for economic stability in numerous regions. This review recognizes the vulnerability of maize production to climate variability and extreme weather events, such as drought. Reduced maize yields can reverberate through the entire food supply chain, affecting food prices and the livelihoods of millions of people worldwide.

Sub-Saharan Africa is particularly susceptible to the adverse impacts of climate change-induced drought events, resulting in severe consequences for maize production (Dlamini et al., 2016). This region faces unique challenges, including limited access to irrigation systems and a heavy reliance on rain-fed agriculture. Smallholder farmers, who constitute a substantial portion of maize producers in Sub-Saharan Africa, are especially vulnerable to variations in rainfall patterns and prolonged droughts.

While the literature reviewed above provides valuable insights into the multifaceted relationship between drought and maize yields, it is essential to acknowledge the existing gaps in understanding. Most of the studies reviewed primarily focus on broader regional or national contexts, and there is limited research that specifically addresses the localized effects of drought on maize yields in Palabek Ogili Sub County, Lamwo district. Consequently, the unique dynamics and adaptive strategies employed by farmers in this specific region remain under explored.

While the existing literature offers valuable insights into the relationship between drought and maize yields, it primarily focuses on broader regional or national contexts. There is a notable lack of research specifically addressing the localized historical patterns of drought in Palabek Ogili sub county, Lamwo district.

2.2 The relationship between Drought and Maize Yields

Drought, a persistent global climatic challenge, significantly affects agricultural productivity, with its impacts being felt most acutely in regions like sub-Saharan Africa, where rain-fed agriculture is predominant (WMO, 2012). Globally, droughts lead to reduced soil moisture and water stress in crops, severely affecting growth and productivity (Lesk et al., 2016). These effects are particularly evident in staple crops like maize, which is crucial for food security in many developing countries.

In various regions, studies have documented the adverse effects of drought on maize yields. For instance, research conducted in neighboring Kenya by Ouma and Odongo (2019) demonstrated that drought events led to significant yield reductions, triggering food insecurity and income losses among farmers. Similarly, a study by Mugendi et al. (2018) in a semi-arid region highlighted the negative impact of drought on maize production, with yield losses primarily attributed to reduced rainfall and increased temperatures.

As the focus shifts to Uganda, particularly Northern Uganda, the threat posed by drought becomes increasingly pronounced. The region's semi-arid climate and erratic rainfall patterns make it especially susceptible to drought events (FAO, 2018). Over time, drought occurrences in Uganda, including in Lamwo district, have exhibited alarming trends—becoming more frequent, intense, and prolonged, which exacerbates their impact on agriculture (Ongoma et al., 2020).

In Northern Uganda, maize serves as a staple crop for smallholder farmers and is integral to food security and livelihoods (UBOS, 2021). The region's vulnerability to drought means that any decline in maize yields directly threatens the well-being of the local population. Recent studies have called for localized research to better understand the specific impacts of drought on maize yields in this region (Musau et al., 2020).

Assessments of drought's impact on maize production in Uganda reveal substantial yield reductions during drought years, contributing to food insecurity, particularly among vulnerable populations (Nakawuka et al., 2020). In regions like Northern Uganda, households are especially susceptible to food scarcity due to drought, as it not only reduces maize yields but also leads to increased food prices, thereby weakening household purchasing power (Ojara & Mugonola, 2019).

The consequences of declining maize yields extend beyond immediate food availability. Research indicates that such reductions threaten the economic stability of farming households in Northern Uganda, leading to reduced incomes and diminished resilience to future shocks (Kizito et al., 2021).

In response to these challenges, recent initiatives in Uganda have focused on enhancing resilience among maize farmers. These efforts include promoting drought-tolerant maize varieties, improving water management practices, and providing climate-smart agricultural training (MAAIF, 2020). Moreover, studies underscore the importance of farmer-led adaptation strategies in mitigating drought impacts on maize yields in Northern Uganda (Abenakyo et al., 2021).

Understanding the timing and severity of drought events is essential for assessing their impact on maize yields, particularly in areas like Palabek Ogili Sub County, Lamwo district. The resilience of maize farming to drought hinges on various factors, including farmers' adaptation strategies, choice of maize varieties, and soil management practices (Deressa et al., 2011). Farmers in drought-prone areas often employ strategies such as intercropping, early planting, and the use of drought-resistant maize varieties to mitigate the effects of water scarcity (Kassie et al., 2018). Hence the need to explore the effects of drought on maize yields in the context of Palabek Ogili sub county, Lamwo district.

2.3 Adaptation strategies by maize farmers to drought

Understanding how local farmers perceive and respond to drought is a crucial aspect of this objective. Farmers employ various adaptation strategies based on their experiences and knowledge (Alemu et al., 2018). These strategies may include adjusting planting dates, selecting drought-resistant maize varieties, and diversifying crops to spread risk (Morton, 2007). **Government and NGO Initiatives:** Government agencies and non-governmental organizations (NGOs) often play a role in supporting farmers' adaptation to drought. For example, the Uganda Ministry of Agriculture, Animal Industry and Fisheries may provide extension services, training, and access to drought-resistant seeds (World Bank, 2019). NGOs like CARE and World Vision may implement projects aimed at building community resilience to drought (CARE International, 2020). **Water Management Practices:** Effective water management is critical for mitigating the impacts of drought in agriculture. Farmers in Palabek Ogili Sub County may employ techniques such as rainwater harvesting, small-scale irrigation, and efficient water use practices (Bekchanov et al., 2016). Understanding the prevalence and effectiveness of these practices is essential.

To navigate the challenges posed by drought, farmers in Africa have developed and implemented a range of adaptive strategies. These strategies often draw upon traditional knowledge and practices. For instance, Ndiaye et al. (2019) found that farmers in Senegal adjust planting dates to coincide with anticipated rainfall patterns and utilize drought-tolerant maize varieties when available. These adaptation measures reflect the resilience and resourcefulness of African smallholders in the face of climate variability.

East Africa, with its diverse agro-ecological zones, is particularly susceptible to climate change impacts, including drought events. Tesfaye et al. (2019) conducted research in the region, emphasizing the necessity of comprehensive climate adaptation policies to safeguard maize production. These policies, the study argued, should be tailored to local conditions and aligned with broader national and regional climate resilience strategies.

Role of Indigenous Knowledge: Indigenous knowledge and traditional practices also play a significant role in farmers' adaptation to drought (Owuor et al., 2017). This objective should explore how local knowledge, passed down through generations, contributes to the resilience of farming communities in the face of water scarcity. **Policy and Program Evaluation:** Evaluating the effectiveness of government policies and NGO programs in supporting farmers'

adaptation to drought is a key component of this objective. This involves assessing the reach and impact of initiatives, identifying areas for improvement, and making recommendations for enhancing their effectiveness (Fisher et al., 2018).

Consequently, there is a need for a focused study that assesses meteorological drought patterns and its direct effects on maize yields in Palabek-Ogili Sub County, Lamwo district, providing insights that could inform targeted interventions and adaptation strategies for the local farming community.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The chapter presents the research procedure including description of the study area, research design, study population and sample size; data collection techniques, data research instruments, sampling methods and procedures, data analysis techniques, data quality management and ethical considerations.

3.1 Research Design

The study adopted a cross-sectional research design targeting farm household-level data. Studies including (Amengor et al., 2022; Utouh, 2024) have demonstrated how cross-sectional research has been effectively used to study the impacts of drought-tolerant maize varieties on yield, risk, and resource use in similar agricultural contexts in Africa. The design provides a strong methodological precedent for applying mixed methods to understand the influence of drought on maize yields in Palabek-Ogili Subcounty, Lamwo district in a Ugandan context. In addition, the cross sectional design involves collecting data on the variables of interest at a single point in time, rather than tracking changes over an extended period, thus its applicability for short time research projects as underscored by scholars such as Chombo et al., (2018); Mugagga et al., (2020) and Simtowe et al., (2019).

3.2 Study Area

3.2.1 Location

The study was conducted in Palabek-Ogili Sub County, Lamwo District, as shown in Figure 1. Palabek-Ogili Sub County is in Lamwo District in the Northern Region of Uganda and comprises four parishes, Paracele, Apyeta, Lugwar, and Padwart, along with 70 villages. The sub county lies between longitudes 32°10' E to 32°35' E and latitudes 2°50' N to 3°55' N. Palabek-Ogili is the westernmost sub county of Lamwo District, bordered by Amuru District to the west, Palabek-Kal sub county to the east, and Palabek-Gem sub county in the southeast.

Palabek-Ogili Sub County was selected based on its significance as a maize-growing region and its vulnerability to drought events, given the seasonal variability in rainfall (UNDP, 2020). The selection was informed by consultations with local agricultural experts, government

offices, and community representatives to ensure the study's relevance and applicability to the local context (UBOS, 2020). This localized focus allowed for a comprehensive understanding of the environmental and socio-economic conditions affecting maize production in the area.

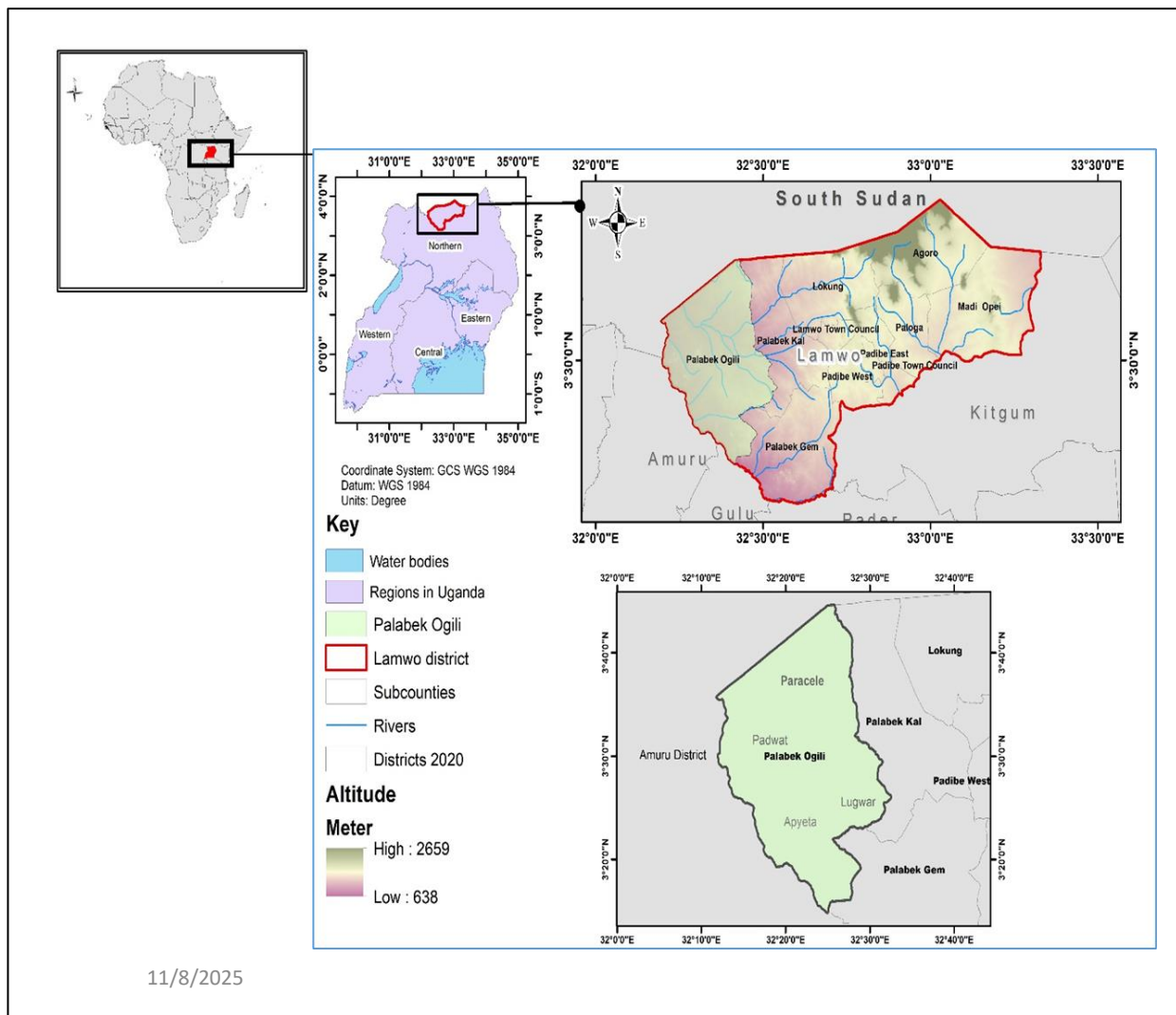


Figure 2: Location of the study area

In addition, the sub county hosts a community of South Sudanese refugees and has experienced a significant increase in pressure on its natural resources since the establishment of the Palabek refugee settlement in 2016. The competition for limited resources between refugees and host community members has exacerbated/intensified environmental degradation leading to shift in climate conditions from the normal manifested through prolonged droughts and reduction in rainfall.

3.2.2 The vegetation

The dominant vegetation in Palabek Ogili Sub County consists of savannah woodland. The common tree species found in the area include the Shea nut butter tree, locally called “awa” in the Madi language and “yaa” in Acoli language (Office of the Prime Minister (OPM), 2018).

3.2.3 Climate

The area experiences a tropical savanna climate, characterized by warm temperatures and distinct wet and dry seasons. The annual mean temperature in the district is around 28.8°C, which is slightly higher than the national average of 23°C for Uganda. The region typically receives about 1,200mm to 1,450 mm of rainfall per year, with the wettest months being from April to October. However, recent years have seen increased variability in rainfall patterns, with some years experiencing prolonged droughts while others witness unusually heavy downpours (Japan International Cooperation Agency, 2013). During the wet season, the region experiences regular and often heavy rainfall, which negatively affects agricultural productivity. The dry season typically occurs from December to February, during which time rainfall is significantly reduced, and temperatures rise. This dry season can lead to water scarcity, impacting agriculture and water resources (UBOS, 2020).

3.2.4 Main economic activities

The economy of Palabek Ogili sub county, Lamwo district is largely dependent on agriculture, both subsistence and commercial and livestock rearing. However, the area faces depletion of grazing lands and water sources for their livestock (UBOS, 2020; Uganda Bureau of Statistics (UBOS), 2020).

3.2.5 Relief and topography

Palabek-Ogili Sub County, Lamwo district lies at an average elevation of approximately 962 meters above sea level and is characterized by a relatively flat to gently sloping terrain, with Ogili Hill—rising to about 1000 meters as the most prominent topographic feature. This hill not only defines the local landscape but also influences water runoff and microclimatic conditions in the surrounding area. The region is situated near Paluda and the village of Padwat, both of which share similar geographical characteristics. The soils in Palabek-Ogili sub county, Lamwo district are predominantly ferralsols and acrisols, known for their moderate fertility and reddish-brown color, typical of tropical savanna environments. While these soils can

support maize cultivation, their productivity is highly dependent on moisture availability and organic matter content, making them vulnerable to prolonged drought and soil degradation. The combination of gentle relief, moderately fertile soils, and exposure to erratic rainfall patterns significantly affects agricultural potential and necessitates sustainable land management practices to support resilient maize production.

3.3 Study population

The study population included households that grew maize out of the total estimated number of households, which was reported to be 1,953 according to the latest census data from the Uganda Bureau of Statistics (UBOS, 2024). The population comprised households per parish, specifically: Apyeta with five hundred and twenty-six (526) households, Lugwar with four hundred and seventeen (417) households, Padwart with six hundred (600) households, and Paracele with three hundred and seventy (370) households. However, based on the major crops grown among these households, maize growers were purposively selected for the study. In addition to the maize-growing households, the study also included agricultural officers, production officers, extension workers, parish development model workers, and prominent farmers in the sub county. Furthermore, meteorological officers and maize grain millers in the area were part of the study population. This diverse selection of participants aimed to provide a comprehensive understanding of the impacts of drought on maize yields and the adaptation strategies employed by farmers in Palabek-Ogili Sub County.

3.4 Sample size and procedure

3.4.1 Sample size

To compute the sample size, the study used the Krejcie and Morgan's (1970) formula. According to the Lamwo District Area Specific Report, there were a total of 1,913 households in Palabek Ogili sub-county in 2024. A sampling frame of 1,913 households in Palabek Ogili is appropriate since crop production, particularly maize, is the dominant livelihood activity in the region. Therefore, using Krejcie and Morgan's (1970) formula, an appropriate sample size for the household questionnaire interviews was computed as follows:

$$n = \frac{x^2 NP (1 - P)}{e^2 (N - 1) + x^2 P (1 - P)} \dots \dots \dots \text{Equation (1)}$$

Where;

n , is the sample size,

N , is total number of the targeted population

e , is the level of precision and,

χ^2 , is the chi square for 1 degree of freedom at the desired confidence level (3.841).

This method of sample size determination has been recommended by many scholars for the known population like the maize growers in Palabek with unknown total number (Hemanta & Hazarika, 2016).

Table 1: Parameters and values used for sample size calculation

Parameters/variables	Substitution values
N	1,913
N-1	1,912
E	0.05
e^2	0.0025
χ^2	3.841
1-P	0.5
P	0.5
n (Sample size)	320

After that, proportionate samples for each parish were computed using the Cochran's (1977) formula of sample size determination as shown in table 2.

Table 2: Proportionate sample size

Sample size (n) entire sub county		320
Palabek sc (N)	1,913	
Parishes	Number of Households	Proportionate sample
Apyeta	526	88
Lugwar	417	70
Padwat	600	100
Paracele	370	62
Total	1,913	320

3.4.2 Sampling Procedure

The study adopted a snowball sampling procedure, which involved a non-probability sampling method where initial participants were asked to recommend others who met the study criteria. Since the exact number of households growing maize was unknown, even in existing records, the snowball sampling process continued until the desired sample size was reached. This

method proved particularly useful when studying populations that were hard to reach or not publicly known, making it well-suited for cross-sectional research. It provided a flexible way to study populations that had not been extensively examined before, such as maize farmers in the specific context of Palabek-Ogili Sub County.

3.5 Data Collection Methods and Instruments

3.5.1 Household Survey

Interviewer-Administered questionnaires were used to collect information from respondents in selected households. Both open-ended and closed-ended questions were included in the questionnaire to facilitate face-to-face interviews. These interviews were instrumental in assessing the impacts of drought on maize yields and the adaptation strategies employed by farmers. The household questionnaire interviews were appropriate because they allowed for face-to-face probing, reducing the risk of misinterpretation by respondents. This method also helped capture in-depth information about the challenges and nature of drought adaptation strategies used by the farmers, with questions designed to facilitate easy collection of comprehensive data.

3.5.2 Key Informant Interviews

Key informant interviews were conducted with individuals such as the sub-county production officer, district community development officer, district environmental officer, and sub-county agricultural extension officers. A checklist comprising purely open-ended questions guided these interviews.

3.5.3 Satellite Data Collection

Historical climate data on rainfall and temperature which was obtained from Precipitation with Station data (CHIRPS) and Rainfall Estimates from Measured and Satellite Observations (drought early warning and environmental monitoring freely accessed via <https://www.chc.ucsb.edu/data/chirps> spanning last thirty years. In climatology, thirty years and above is considered the standard for defining climate normal and assessing climate change. The World Meteorological Organization (WMO) recommends using 30-year periods to calculate climate statistics and compare current conditions to a historical baseline. In addition, a 30-year period is long enough to capture the natural variability in weather patterns, including the occurrence of extreme events like droughts. This allowed the researcher to assess the

duration, intensity, severity, and impacts of droughts on maize yields over a meaningful time frame (Simtowe et al., 2019). Precipitation/ rainfall and temperature are key indicators of agricultural drought (Yihdego et al., 2019). These data was used to monitor drought events and assess their severity and duration in Palabek Ogili Sub County, Lamwo district as also used by Nalwanga et al., (2024) in providing insights into meteorological drought of Uganda's cattle corridor through past trends.

3.6 Data Analysis

A number of methods were used in the analysis of data depending on the type of data and objective, for instance.

3.6.1 The Standardized Precipitation Index

The Standardized Precipitation Index (SPI), was used to analyze historical rainfall data in objective one which was to determine the historical patterns of drought in Palabek-Ogili Sub County, Lamwo district from 1980 to 2020. SPI was used to analyse rainfall data because other indices require several climate data sets which in most cases are lacking in Uganda context. And the fact that Standardized Precipitation Index uses only precipitation data to model drought gave a justification for its use in assessing drought and its effects on maize yields in Palabek Ogili sub county, Lamwo district.

As recommended by the World Meteorological Organization (WMO), (SPI) was utilized in objective one which was to determine the historical patterns of drought of Palabek Ogili sub county, Lamwo district from 1980 to 2020. This index calculation depended on long-term precipitation data. The SPI was generated using the SPI function in R, which calculated SPI following the method commonly employed by Nalwanga et al., (2024). This involved standardizing the cumulative distribution function (CDF) of precipitation based on a gamma distribution. Thus, for a given CDF series $X_1, X_2, \dots, X_n$ the SPI_i was computed as follows:

$$SPI_i = \frac{X_i - \bar{X}}{S_x} s$$

If X_i represents the CDF of the Gamma precipitation distribution, $\bar{X}$ is the mean, and S_x is the standard deviation. The CDF can be generated for other functions, but the study employed the Gamma function. The SPI denotes a divergence from the mean and is consequently given in standard deviation units. In this analysis, the historical period is forty years (1980-2020). Nalwanga et al., (2024) used the classification system (Table 1) to identify drought intensities

based on the SPI. A negative SPI score suggests a lack of precipitation (dry circumstances), whereas a positive value implies an abundance of precipitation (wet conditions).

Table 3: Standardized Precipitation Index (SPI)

SPI Values	Classification
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near Normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 and less	Extremely dry

3.6.2 Pearson's correlation coefficient (r).

The Pearson's Correlation Coefficient was used in objective two which was to investigate the impacts of drought on maize yields in Palabek Ogili Sub County, Lamwo district. It was used to analyze the relationship between drought and maize yields in Palabek-Ogili Sub County, Lamwo district.

The Pearson's correlation coefficient (r) is a statistical measure that evaluates the strength and direction of the linear relationship between two continuous variables. In this study, Pearson's correlation coefficient was used to establish the relationship between the impacts of drought and maize yields in Palabek-Ogili Sub County, Lamwo District.

Formula for Pearson's correlation coefficient.

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}}$$

Where;

X_i : value of meteorological drought (SPI) for year i .

Y_i : Maize yield for year i

$\bar{X}$: Mean of meteorological drought

$\bar{Y}$: Mean of maize yields.

r: Pearson's correlation coefficient (ranges from -1 to 1)

Interpretation

$r > 0$: Positive correlation (more rainfall = high yields)

$r < 0$: Negative correlation (drought = low yields)

$r = 0$: No linear correlation.

3.6.3 Thematic analysis

Thematic analysis was used in objective one, two and three to analyze the qualitative data which was obtained through key informant interviews. This was to validate the quantitative data that was were analyzed using quantitative methods in these respective objectives and to reveal the perceptions, meanings and experiences of the respondents that numbers alone cannot adequately convey.

3.6.4 Frequencies and percentages

This method was used in objective three which was to assess the adaptation strategies of maize farmers to drought in Palabek-Ogili sub county, Lamwo district.

Frequencies and percentages were used to analyze the data on the adaptation strategies used by maize farmers to drought in Palabek-Ogili Sub County, Lamwo district. This approach provided a straightforward way to identify the most and least common adaptation strategies used by maize farmers in Palabek Ogili sub county, Lamwo district. This can help policymakers and agricultural extension officers to focus their efforts on promoting effective adaptation practices and addressing any gaps in current strategies.

3.7 Data Quality Management

3.7.1 Reliability

Reliability refer s to the extent to which data collection tools are consistent, free from both systematic and random errors, and capable of producing similar results over time (Taherdoost, 2016). In the context of this study, which assessed drought severity and its impacts on maize yields in Palabek-Ogili Sub County, Lamwo district questionnaires and interview guides served as the primary data collection tools. Various approaches were employed to test and improve their reliability.

First, a pilot study was conducted using face-to-face interviews with 10 purposively selected smallholder farmers over four days. This pilot study helped refine the questionnaires and interview guides by removing unnecessary questions and restructuring unclear ones, ensuring alignment between conceptual categories in the tools and operational categories in the field. Additionally, a test-retest reliability procedure was performed to establish the stability and consistency of both the questionnaires and interview guides.

Through these measures, the study aimed to enhance the reliability of the data collection instruments, ensuring that they accurately captured information related to drought impacts on maize yields. By focusing on reliability, the researcher sought to strengthen the overall validity of the findings, contributing to a more robust understanding of the challenges faced by maize farmers in Palabek Ogili Sub County.

3.7.2 Data validity

Validity in this study involved the extent to which the data collection instrument measures what it is intended to measure. In this study, content and construct validity were assessed for the questionnaires and interview guides before data collection. Content validity indicates how well the content of a test (i.e., questionnaire) represents the domain it is supposed to cover, while construct validity reflects an instrument's ability to measure an abstract concept or social construct (Taherdoost, 2016). The data collection instruments included various categories and questions that aligned with the study's objectives. To ensure content validity, the researcher had the research instruments reviewed by the experts from the Department of Geography to ascertain the face and content validity.

3.8 Limitations and Delimitations

The study faced several limitations in accurately assessing the historical patterns of meteorological drought and their impacts on maize yields in Palabek-Ogili Sub County, Lamwo District. A major challenge was the scarcity and inconsistency of meteorological data from 1980 to 2020 due to the sparse distribution of weather stations in the region and poor historical record management. Although satellite-based datasets such as the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) were utilized to supplement ground observations, gaps and inconsistencies still affected the precision of trend analysis. Additionally, some quantitative agricultural data were unreliable or incomplete, prompting the researcher to rely partly on farmers' perceptions and recall of drought impacts. This limited the

ability to draw purely data-driven conclusions. The study was limited to Palabek-Ogili Sub County and focused specifically on maize not a specific variety yet some specific variety of maize may not be affected by drought, excluding other crops and external socio-economic factors that may also influence yield outcomes. Despite these limitations, the study provides valuable insights into localized drought effects and farmer responses within a data-constrained environment.

3.9 Ethical consideration

The researcher had approval of her study proposal by the Department of Geography and She then obtained an introductory letter from the Dean faculty of Education and Humanities which she presented to the authorities of Lamwo district to seek for permission to conduct the study in the area. The researcher obtained informed consent and voluntary participation from the respondents and then she assured them that the information obtained would be used to study purpose only.

CHAPTER FOUR

PRESENTATION AND INTERPRETATION OF RESULTS

4.0 Introduction

This chapter presents and interprets the key findings of the study conducted in Palabek-Ogili Sub County, Lamwo District. The chapter is organized in alignment with the study's three specific objectives, which guided both the data collection and analysis processes. These objectives include: (i) determining the historical patterns of drought from 1980 to 2020; (ii) investigating the relationship between drought and maize yields; and (iii) assessing the adaptation strategies employed by maize farmers to drought.

4.1 The Historical Patterns of Drought in Palabek Ogili sub county, Lamwo district from 1980 to 2020

The results for the SPI are presented in Figure 3 and 4. As seen from the table, the severity of drought was measured by SPI01, SPI03, SPI06, and SPI12. However, this study primarily relied on SPI01 which reflects immediate drought conditions and SPI03 which reflects short-term drought conditions to assess the historical patterns of drought and its effects on maize yields. These indices provide a detailed picture of how drought has evolved over the past four decades and how these variations in drought conditions have affected the region.

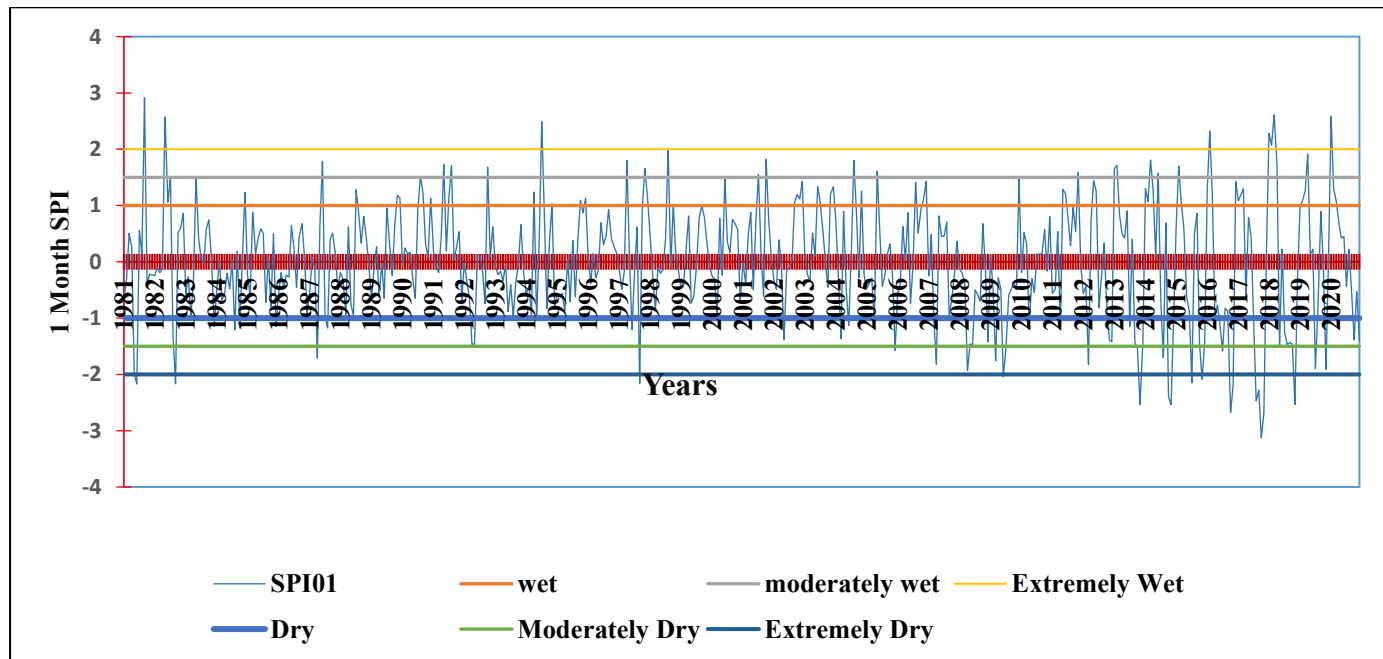


Figure 3: 1 month SPI on intensity and duration of extremely dry events for the period 1980-

2020 in Palabek Ogili sub county, Lamwo district in Uganda.

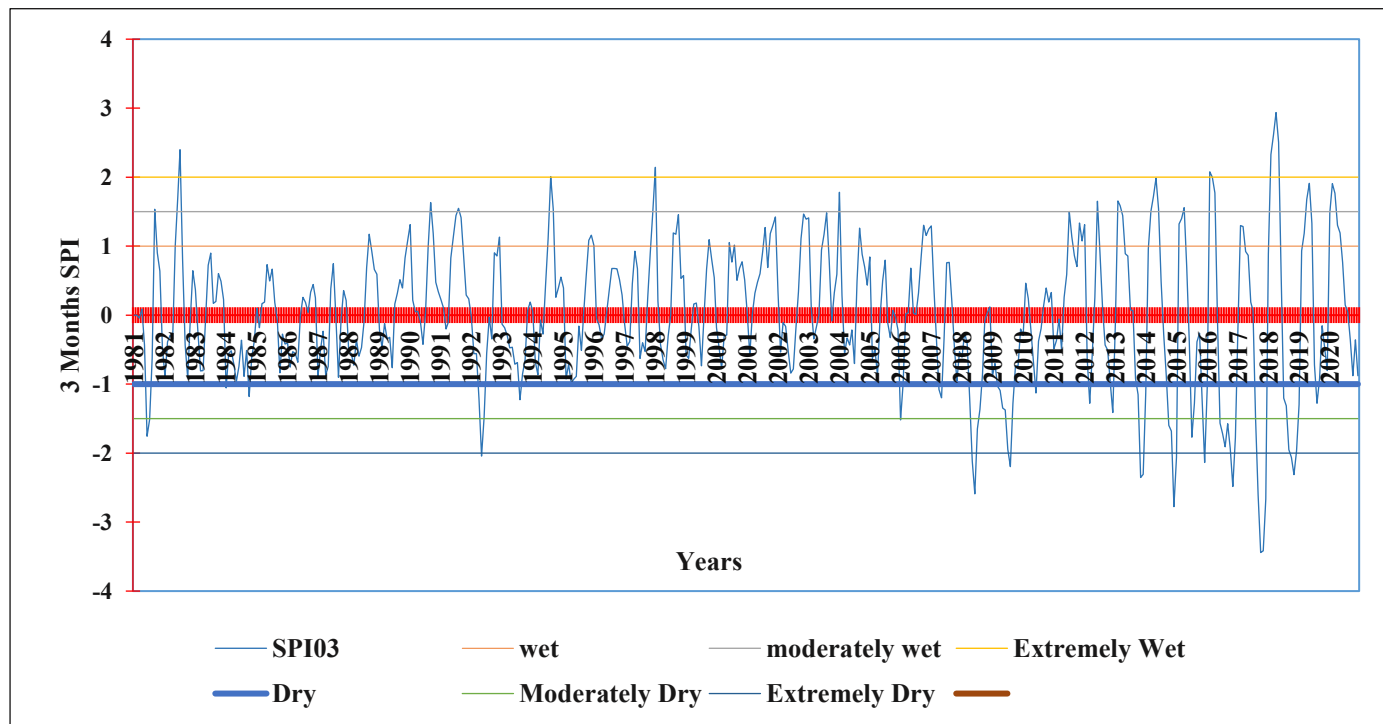


Figure 4: Three months SPI on the intensity and duration of extremely dry events for the period 1980-2020 in Palabek Ogili sub county, Lamwo district in Uganda.

4.1.1 Severity of Drought

The severity of drought in the study area was assessed using the Standardized Precipitation Index (SPI) at one-month (SPI01) and three-month (SPI03) timescales. The SPI01 data reflected short-term variations, while SPI03 provided insights into seasonal drought patterns. From the SPI01 graph, extreme dry conditions below -2.0 were observed several times, particularly between the years 1984–1986, 2005–2006, 2016–2017, and around 2018–2019. These periods indicated high drought severity, with prolonged negative SPI values suggesting intense short-term moisture deficits that could have impacted crop productivity and water availability.

Moderate drought events (SPI between -1.0 and -1.5) appeared frequently across the four-decade period, implying recurrent stress conditions. Although not all these events were extreme, their cumulative impact on the agricultural and hydrological systems was substantial. The alternating pattern between moderately wet and moderately dry phases reflected unstable rainfall distribution, which heightened the vulnerability of the region's ecosystems and livelihoods dependent on rain-fed agriculture.

The SPI03 results reinforced this trend, showing consistent drought intensities recurring at approximately decadal intervals. Severe droughts below -2.0 on the SPI03 scale were particularly evident in the early 1980s, early 1990s, mid-2000s, and late 2010s. These severe events suggest that both short-term and seasonal droughts have intensified over time, aligning with broader climatic variability patterns observed in East Africa.

Overall, the analysis revealed that drought severity had increased in both magnitude and frequency over the years. While some extremely wet episodes ($SPI > 2.0$) were also recorded—especially around 1998, 2007, and 2019—they were short-lived and followed by severe dry spells. This irregular oscillation between extremes indicated a growing climatic instability that has strained agricultural resilience and regional food security.

4.1.2 Duration of Drought

The duration of drought events was examined through the persistence of negative SPI values across both the one-month and three-month indices. The SPI01 plot demonstrated that short-lived droughts lasting one to three months were common throughout the study period. However, in several instances, negative SPI values persisted beyond six months, indicating extended dry conditions that could have affected multiple planting seasons. For example, the continuous low SPI values between 1984–1985 and again between 2016–2017 revealed multi-month drought episodes that likely disrupted crop growth cycles.

Similarly, the SPI03 graph, which captures seasonal variations, showed prolonged drought events extending over several consecutive seasons. Notably, extended drought durations were observed between 1983–1986, 1999–2001, and 2016–2018. These long-term deficits reflected cumulative rainfall shortages over multiple months, making recovery difficult for both natural vegetation and agricultural systems. Such sustained droughts had profound implications for soil moisture depletion, groundwater recharge, and overall ecosystem sustainability.

The persistence of drought conditions also appeared to increase over time, particularly after the year 2000. Longer dry spells in recent decades suggested that droughts not only became more severe but also more enduring. This shift could be associated with broader climate change influences, including rising temperatures and erratic rainfall patterns that prolong recovery periods between drought episodes.

In summary, the duration of droughts in the region evolved from relatively short and infrequent events in the early 1980s to longer and more persistent occurrences in the 2000s and 2010s.

This temporal pattern underscored the increasing challenge of managing water resources and sustaining agricultural productivity in the face of prolonged climatic stress.

Table 4: Thematic Analysis of Meteorological Drought in Palabek-Ogili Sub County (1980–2020)

Theme	Respondent (Code)	Key Responses
Major Drought Events (1980 - 2020)	A	<i>“The major droughts I recall happened in 1993, 2000, and 2016. The one in 2000 was particularly devastating.”</i>
	B	<i>“The drought in 2016 is memorable. It led to a complete failure of crops in my area, and many families lost everything.”</i>
	C	<i>“There were severe droughts in 1997 and 2009. The 1997 drought was especially harsh for farmers in this region.”</i>
	D	<i>“I remember the 2000 drought very well. The maize crops didn’t mature, and many people resorted to other sources of income.”</i>
Frequency and Severity of Droughts Over Time	A	<i>“The frequency of droughts has definitely increased. It used to be every 5 to 10 years, but now it’s more frequent, every 3 to 5 years.”</i>
	B	<i>“Yes, the severity has also increased. In the past, droughts were not as intense. But the ones we face now seem to last longer and affect a larger area.”</i>
	C	<i>“Over the last 40 years, droughts have become a more frequent occurrence. The ones in 2016 and 2020 were particularly severe.”</i>
	D	<i>“The past decade has seen an increase in droughts. The situation has worsened, and droughts are now almost annual.”</i>
Indicators to Predict or Notice the Onset of Drought	A	<i>“Farmers here usually rely on the behavior of birds and insects. If the birds migrate earlier than usual, it signals a dry season.”</i>
	B	<i>“The local trees start shedding leaves early, and the ants become more active. These signs are seen as indicators of an upcoming dry period.”</i>
	C	<i>“We also look for changes in the behavior of the wind and the sky. When the winds are harsher and the sky becomes hazy, drought is likely.”</i>
	D	<i>“The patterns of rain change. If there is very little rainfall during the first planting months, we know the drought will be severe.”</i>

Theme 1: Major Drought Events Remembered in Palabek-Ogili sub county, Lamwo district (1980–2020)

Respondent A (Production Officer): *“The 1999 drought was one of the worst I’ve ever seen. Crops dried before maturity, and families survived mostly on relief food supplied by humanitarian agencies.”* This drought struck during a critical phase of the agricultural cycle, where maize and millet were already flowering. According to A, granaries that once held the community’s food reserves were left empty. Many residents depended on food rations distributed through humanitarian convoys, particularly from NGOs such as World Food Programme. The drought led to a decline in community morale, increased household debts due to failed investments in inputs, and triggered rural-urban migration in search of livelihoods.

Respondent B (Agricultural Officer): *“The 2006 drought was especially harsh. It followed a season of promise, and people had invested in hybrid maize seeds. Unfortunately, the rains*

stopped abruptly in May.” The abrupt halt of the rains dashed the expectations of higher yields from improved seeds. Many farmers who had borrowed money to purchase seeds were unable to repay, which led to loss of trust in agricultural credit systems. The drought forced entire villages to abandon maize and resort to emergency crops like sweet potatoes and pumpkins. Agricultural extension services struggled to respond due to the sheer scale of the failure, leading to a breakdown in farmer trust toward formal advisory services.

Respondent C (Meteorological Officer): *“In 1983, we observed an extended dry spell that lasted over three months, which disrupted the entire cropping cycle.”* The meteorological officer noted that this early event marked the first time that traditional rainfall patterns were severely disrupted. Farmers who planted based on their indigenous calendars lost entire harvests. Reports from that year showed school dropout rates increased due to children being engaged in finding food or working in exchange for meals. The officer emphasized that local weather records indicated it was a La Niña year, yet knowledge about global climate phenomena was non-existent among local communities.

Respondent D (Agricultural Extension Worker): *“The 2017 drought devastated even the cassava, which is normally drought-resistant. People came to me asking what else they could plant.”* This event exposed the increasing intensity of drought in the sub-county. Extension staff found themselves overwhelmed by farmer demands and limited by the absence of drought-resilient alternatives. Drought-resistant seed distribution schemes had not reached the area, and the extension system lacked mobility to cover all affected households. Cassava fields withered, forcing families to forage in bush lands for wild foods, especially tamarind, and to slaughter livestock prematurely, depleting household wealth.

Respondent A (Production Officer): *“Back in 1991, the rainy season started well but ended too quickly. Farmers were confused because it had never happened that way before.”* This unpredictability altered farmers’ confidence in their own knowledge systems. The shortening of the rainy season caught many unprepared. Farmers who had invested in land tillage and weeding found their efforts wasted, as seeds failed to germinate or died shortly after sprouting. Village-level seed banks were depleted due to consecutive losses, leaving many unable to replant. According to the officer, this led to food rationing, skipping of meals, and increased levels of household hunger.

Theme 2: Changes in Frequency and Severity of Droughts in Palabek Ogili sub county, Lamwo district (1980–2020)

Respondent B (Agricultural Officer): *“Today, droughts happen almost every two to three years, compared to once in a decade before 2000.”* This trend has made farming a high-risk venture in Palabek-Ogili sub county, Lamwo district. According to B, the pressure on extension services has also intensified. Where previously one good harvest could sustain a household for two seasons, families now face chronic food insecurity. The changing climate has also altered community dynamics, with more youths migrating for work, leaving only elderly farmers in the villages, further weakening agricultural productivity.

Respondent C (Meteorological Officer): *“There’s a clear trend in rising temperatures and decreasing rainfall totals across Palabek-Ogili. The data from our station shows a 15% decline in annual precipitation since 1990.”* C emphasized that climate data increasingly shows a decoupling of rainfall amount from expected crop output. Rainfall patterns have shifted from steady, prolonged showers to short, intense bursts that fail to penetrate the soil adequately. The reduction in water table levels, observed from shallow boreholes and streams, confirms long-term drying of the ecosystem, negatively impacting not just crops but livestock and water-dependent rural industries.

Respondent D (Extension Worker): *“In the past, people could easily predict and adjust to drought, but now it comes suddenly and hits hard.”* According to D, rapid-onset droughts have increased. Crops are planted with initial rain but perish when the rains vanish unexpectedly. This suddenness gives farmers little time to prepare. Extension staff often receive panic calls from parishes like Ogili and Apyeta, but lack the tools or budget to respond rapidly. The unpredictability also leads to wastage of inputs like fertilizer and pesticides applied just before drought hits, compounding economic losses.

Respondent A (Production Officer): *“The 1980s had occasional dry spells, but since the early 2000s, it’s like we are in a permanent drought.”* The officer noted that this situation has changed farming from a predictable economic activity into a gamble. Women, who are the primary food growers, have especially borne the brunt, with increased burdens of fetching water and ensuring food availability. Drought also affects social programs such as school feeding and immunization campaigns that depend on a nourished population for effectiveness. The officer stressed that current extension strategies must shift toward resilience building.

Respondent B (Agricultural Officer): *“The droughts are becoming more severe and unpredictable. Even when it rains, the moisture does not last in the soil like it used to.”* B blamed this on widespread tree cutting and soil degradation. Most soils have become bare, and

the loss of vegetative cover has led to erosion and faster evaporation. Without trees, there's little shade or windbreak for crops, and the natural cycle of moisture retention has broken down. The officer warned that if these trends continue, food insecurity will worsen despite interventions like improved seeds.

Theme 3: Traditional Indicators of Onset of Drought in Palabek Ogili Sub County, Lamwo district

Respondent C (Meteorological Officer): *“The flowering of the ‘otwee’ tree (African mahogany) used to signal the beginning of rains, but now it flowers out of season.”* C observed that this phenomenon has disrupted traditional planting calendars. Farmers who relied on this natural clock found themselves planting too early or too late. He attributed this to temperature changes and shifts in seasonal wind patterns that influence plant behavior. This disconnection between biological cues and weather conditions has reduced farmer trust in traditional practices.

Respondent D (Extension Worker): *“We used to listen to the croaking of frogs and movement of termites. These signs are now misleading or absent.”* This shift has been particularly disorienting for older farmers. D recounted how community elders would predict rainfall within a few days based on the loudness of frog croaks. Now, those same cues have become unreliable. D warned that this breakdown of ecological indicators has eroded community confidence and made weather planning a guessing game, causing some to plant multiple times in one season.

Respondent A (Production Officer): *“Old men used to say if the wind from the east was strong in February, the rains would delay. That prediction worked well before.”* A noted that now these winds are either absent or occur in unrelated months, rendering the predictions moot. He explained that villagers used to gather for planting advice based on these observations. Now, fewer community meetings are held, and younger farmers don't consult elders, leading to fragmentation of agricultural planning and more frequent planting failures.

Respondent B (Agricultural Officer): *“The moon and star patterns used by elders have become unreliable. We now advise farmers to supplement with scientific data.”* B stressed the need to blend traditional and modern knowledge. While traditional systems provided reliable long-term orientation, climate variability has made it essential to access meteorological forecasts. The officer cited recent efforts to integrate radio weather bulletins with community sensitization workshops as a hybrid approach to improve decision-making.

Respondent C (Meteorological Officer): *“Before the drought, goats behave differently—restless, refuse food, or bleat constantly. These signs are fading or misinterpreted now.”* C mentioned that some younger farmers ridicule these signs, considering them superstition. However, the loss of such ecological knowledge is regrettable, as it formed a part of the community’s disaster preparedness. The officer called for a documentation project to preserve traditional climate indicators before they disappear completely from local knowledge systems.

4.2 Relationship between drought and maize yields in Palabek Ogili sub county, Lamwo district

Table 5: Correlations between drought and maize yields

Correlations between drought and maize yields		Severity	Intensity	Duration
Maize Yields	Pearson Correlation	.149	.621**	.366**
	Sig. (2-tailed)	.077	.000	.000
	Sum of Squares and Cross-products	487.319	1492.543	1158.284
	Covariance	3.481	16.04	8.273
	N	302	302	302

**. Correlation is significant at the 0.01 level (2-tailed).

The results on the relationship between drought and maize yields in Palabek Ogili sub county, Lamwo district as in table 5 indicated varying levels of relationship between these drought parameters and maize production, providing insight into how different aspects of drought influence crop yields.

The correlation between drought severity and maize yields was found to be strong and positive ($r = 0.692$, $p = 0.01$), indicating that as the severity of drought increased, maize yields tended to decrease. This suggests that severe droughts have a significant detrimental impact on maize production in the region. The statistical significance of this correlation ($p = 0.01$) reinforces the reliability of this finding, showing that the relationship between drought severity and maize yields is not due to chance.

Similarly, the intensity of drought events also demonstrated a moderate and positive correlation with maize yields ($r = 0.621$, $p = 0.01$). Although the relationship was not as strong as that of drought severity, it still indicated that higher drought intensity negatively affected maize yields. The moderate correlation suggests that, while intensity is an important factor, other elements

might also contribute to variations in maize yields, including the duration of drought periods and other environmental conditions.

Finally, the correlation between the duration of drought and maize yields was positive but weaker ($r = 0.366$, $p = 0.01$). This suggests that longer droughts do indeed have a negative impact on maize yields, although the effect is less pronounced compared to severity and intensity. The results imply that while prolonged droughts are detrimental, they may not be as immediately damaging as more intense or severe drought events. Overall, these findings highlight the critical role of meteorological drought characteristics in determining maize production outcomes in the study area.

Table 6: The coefficients

The coefficients table offers more insights into the impact of each predictor (severity, intensity, and length of drought) on maize yields. The unstandardized coefficients (B) reflect the direct effect of each predictor on maize yields, but the standardized coefficients (Beta) demonstrate the relative strength of each predictor.

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	25.444	2.315		10.993	.000
	Severity	-.034	.294	-.023	-.114	.
	Intensity	.881	.132	.751	6.698	.000
	Duration	-.291	.271	-.191	-1.075	.285

a. Dependent Variable: Maize Yields

Severity: The unstandardized coefficient for severity is -0.034, indicating that for each unit rise in drought severity, maize yields are anticipated to decline by 0.034 units, assuming other parameters remain unchanged. The standardized coefficient (Beta = -0.023) is negligible, indicating that severity has a modest influence on maize yields relative to the other variables. The t-value of -0.114 and a significance level of 0.907 ($p > 0.05$) demonstrate that severity is not statistically significant in forecasting maize yields.

Intensity: The unstandardized coefficient for intensity is 0.881, indicating that for each unit increase in drought intensity, maize yields are anticipated to rise by 0.881 units. The positive correlation is further substantiated by the standardized coefficient (Beta = 0.751), indicating that intensity significantly enhances maize yields. The t-value of 6.698 and a significance level of 0.000 ($p < 0.01$) indicate that intensity is a very significant predictor of maize yields.

Length: The unstandardized correlation for length is -0.291, indicating that extended drought periods correlate with a reduction in maize yields. The standardized coefficient (Beta = -0.191) indicates that the impact of duration is comparatively less significant than that of intensity. The t-value of -1.075 and a significance level of 0.285 ($p > 0.05$) demonstrate that duration is not statistically significant in forecasting maize yields in this model.

In conclusion, intensity is the primary predictor of maize yields, exerting a robust and positive influence, while severity and length have smaller impacts and lack statistical significance in this model. The findings indicate that strategies to alleviate drought severity may be crucial for enhancing maize output in the examined region.

The results for the thematic analysis on the data from key informant interviews is here presented in table 7 and the subsections that follow.

Table 7: Thematic Clustering of Responses on Impacts of Drought on Maize Yields

Code	Designation	Theme
A	Production Officer	Drought effects on maize yields
B	Agricultural Officer	Specific drought events and losses
C	Meteorological Officer	Broader agricultural impact of drought
D	Agricultural Extensionist	Farmers' adaptation and changes

Theme 1: Relationship between Drought and Maize Yields

Production Officer (Respondent A): *“In the years I have monitored crop performance, especially from 2005 onwards, maize yields have seen significant declines during prolonged dry spells.”*

The production officer observed a consistent decline in maize yields over the years, particularly due to prolonged dry spells. Maize, being a water-intensive crop, suffers drastically when rainfall is inadequate during critical growth stages like flowering and grain filling. The officer identified that the prolonged dry periods starting in 2005 have become more frequent, causing crops to wither and fail. This trend is evident in the 2017 dry spell, where yields in the region were reduced by over 40%, leading to severe food insecurity and economic stress for local farmers. The officer emphasized the vulnerability of rain-fed agriculture in Palabek-Ogili, where inadequate rainfall for even a couple of weeks results in significant crop damage. The decline in yields represents a broader agricultural challenge and highlights the increasing difficulty in sustaining traditional farming practices in the face of climate change.

Agricultural Officer (Respondent B): *“Drought has changed everything about how maize is grown. We used to expect at least two planting seasons per year, but in dry years, one season fails completely.”* This response reflects a significant change in the agricultural landscape due to drought. Traditionally, farmers in Palabek-Ogili would rely on two planting seasons per year. However, the increasing frequency of dry spells has disrupted this cycle, causing total crop failure in one of the two planting seasons. In 2015, farmers in Lalai Parish experienced a complete failure of their second planting season because rains ceased prematurely. The officer stressed that these irregular patterns make maize farming highly unpredictable. Farmers, who once planted with confidence in both seasons, now face uncertainty, which undermines their economic stability. This pattern highlights the changing dynamics in agriculture, where droughts make it difficult to predict planting seasons or manage risks effectively.

Meteorological Officer (Respondent C): *“From a climatic point of view, rainfall variability has become more unpredictable, making maize a risky crop.”* The meteorological officer discussed how the increased variability in rainfall patterns has created greater risks for maize farming. Historically, farmers could rely on consistent rainfall during specific months, but climate change has led to more unpredictable patterns. The officer noted that the rains no longer follow a predictable schedule, making it difficult for farmers to plan. The 2020 season was a perfect example of this unpredictability, as early rains in March misled farmers into planting, only for dry conditions to set in by May. This resulted in severe crop damage and further emphasized the risks associated with growing maize in such an uncertain climate. The officer’s perspective points to the increasing challenge of managing agriculture under changing climatic conditions and suggests that better forecasting and adaptation strategies are crucial for farmers’ survival.

Agricultural Extension Worker (Respondent D): *“Most of the maize farmers I work with are smallholders who rely entirely on rainfall. When drought hits, they are hit hardest.”* The extension worker highlighted the vulnerability of smallholder farmers who depend solely on rainfall for their maize cultivation. These farmers are particularly susceptible to drought since they lack irrigation infrastructure or the means to adapt to changing weather patterns. In 2019, farmers in Pobar Parish lost over 70% of their maize crop to drought, leading to significant economic hardship. The extension worker explained that these farmers often have limited resources to cope with drought, making them more reliant on external assistance such as food aid or temporary employment. The lack of resilience among smallholders exacerbates the

problem, as they face not only crop failure but also long-term food insecurity. This also reveals a critical need for initiatives that build resilience in small-scale farming communities, such as access to irrigation systems or drought-resistant crops.

Theme 2: Specific Drought Events and Their relationship with Maize Production

Agricultural Officer (Respondent B): *“The 2017 drought was the most devastating in the last decade. Even early planters were not spared.”* The officer shared an example of the 2017 drought, which caused widespread damage despite efforts by farmers to plant early in anticipation of the rain. Even those who planted early were affected when rains failed to materialize, resulting in a total loss of crops for many. The 2017 drought was particularly harsh, affecting farmers across multiple parishes, including Pobar and Lalai. The officer pointed out that maize, which is highly dependent on consistent rainfall, suffered immensely. In this drought, farmers lost not only their current crop but also their source of income, leading to greater financial strain. This event highlights the vulnerability of maize farming to unpredictable climatic conditions, reinforcing the need for better drought management and adaptive farming techniques.

Meteorological Officer (Respondent C): *“In 1999 and 2005, our records show a sharp decline in rainfall totals—almost half of the long-term mean.”* The meteorological officer referred to past drought events in 1999 and 2005, which resulted in significant declines in rainfall, severely affecting maize production. These years are remembered as some of the worst drought years in the region, with rainfall totals dropping to nearly half of the long-term average. The officer explained that such drastic declines in rainfall lead to total crop failure, particularly for water-dependent crops like maize. The historical records of these events provide critical insights into the impact of droughts on maize production and demonstrate the increasing frequency and severity of such climatic events. This data can inform future agricultural strategies to better prepare for and mitigate the impacts of drought.

Agricultural Extension Worker (Respondent D): *“I remember visiting a demo plot in Lobia village in 2015, and there was absolutely nothing to show except dried stalks.”* This statement highlights the severity of the 2015 drought, which affected demonstration plots used to showcase successful farming practices. In Lobia village, a well-maintained demo plot that had been carefully irrigated and managed to demonstrate best farming practices was devastated by the drought, with all crops dying. The extension worker noted that this event had a significant

psychological impact on the local farming community, as even well-managed and irrigated crops were not immune to the extreme conditions. The failure of these demonstration plots led to farmers losing confidence in new agricultural techniques and practices. This emphasizes how drought not only impacts crop yields but also undermines efforts to introduce better farming methods in the region.

Production Officer (Respondent A): *“Even farmers using improved hybrid seeds like Longe 10H lost most of their harvest during the 2018 dry spell.”* The production officer noted that even the use of improved hybrid seeds, such as Longe 10H, which are designed to withstand drought, was not enough to prevent crop failure during the 2018 dry spell. These seeds are known for their ability to resist drought better than traditional varieties, but the extreme conditions in 2018 were too much for even these resilient varieties. The officer emphasized that the severe dry spell, combined with the absence of adequate rainfall during critical periods, led to a significant loss in maize yields, showing that even advanced agricultural technologies have limitations when faced with extreme drought conditions. This highlights the need for diversified farming systems and further research into more drought-resistant crop varieties.

Agricultural Officer (Respondent B): *“During the 2020 lockdown, drought made the situation worse because people could not afford inputs or irrigation.”* The officer shared how the combination of drought and the COVID-19 pandemic worsened the situation for farmers. The 2020 drought was particularly harsh, and the lockdown exacerbated the problem, as farmers could not access essential agricultural inputs like seeds, fertilizers, or irrigation services. The officer observed that many farmers were unable to plant or maintain their crops due to the lack of resources, leading to significant crop losses. This compounded the challenges faced by farmers in Palabek-Ogili, who were already struggling with climate-related issues. The intersection of the pandemic and drought has highlighted the vulnerability of smallholder farmers and the need for integrated solutions to support agricultural resilience.

Theme 3: Changes in Farming Practices Due to Drought

Meteorological Officer (Respondent C): *“Drought has forced many farmers to shift planting dates unpredictably. This messes up the entire cropping calendar.”* This thematic point emphasizes how drought has disrupted traditional farming practices. Due to the unpredictable nature of rainfall, farmers are no longer able to adhere to the established planting calendar. This has led to a scenario where planting is done haphazardly, sometimes too early or too late, with

adverse results. The officer noted that the shift in planting schedules makes it difficult to harmonize farming activities, leading to poor crop performance. This irregularity complicates agricultural planning and makes it harder to predict yield outcomes. The need for adaptive strategies, such as more flexible farming calendars and reliance on weather forecasting, has become increasingly apparent.

Agricultural Extension Worker (Respondent D): *“Seed selection has been affected. Farmers now ask for early-maturing varieties, even if they yield less.”* The extension worker discussed how drought has led to a shift in seed selection, with farmers opting for early-maturing varieties that are less likely to be affected by prolonged droughts. While these varieties allow farmers to harvest before the worst of the drought hits, they come with the trade-off of lower yields. In 2019, for example, farmers in the area switched to early-maturing maize varieties like Longe 4, which can withstand shorter periods of drought, but the yield was significantly lower compared to traditional varieties. This shift reflects a pragmatic approach to mitigate the risk of crop failure but also highlights the ongoing trade-offs that farmers must make in response to drought conditions.

Production Officer (Respondent A): *“Drought makes weeding more difficult because the crops are weak, and weeds dominate.”* This response highlights how drought affects not only planting and harvesting but also routine farm management tasks like weeding. When crops are weakened by drought, they become more susceptible to competition from weeds, which thrive in the absence of sufficient water. Weeding, therefore, becomes a much harder task, as the weak crops can’t outcompete the weeds, leading to further reductions in yields. This also places additional strain on farmers, who have to deal with an increased workload during an already stressful growing season. The production officer noted that this cycle of weakened crops and rampant weeds is a direct consequence of drought, further complicating the already challenging farming environment.

4.3 Adaptation Strategies of Maize Farmers in Palabek Ogili sub county, Lamwo district

The adaptation strategies employed by maize farmers to mitigate the impacts of drought are diverse. Here, percentages, frequencies and chi square tests were used to analyse the relationship between the adaptation strategies used and the proportion of farmers using them based on the data obtained from the household survey. Thematic analysis was then used to analyse data from focus group interviews to establish the farmers' perception on the different adaptation strategies and the probable reasons for their adoption of the same.

The results for the percentages, frequencies and chi square tests are presented in Table 8 below.

Table 8: The adaptation strategies adopted by maize farmers (n=302)

Adaptation Strategy	Frequency (f)	Percentage (%)
Adjusting planting dates	122	40.4
Using drought-resistant maize	83	27.6
Crop diversification	75	24.8
Soil conservation	12	4.1
Mulching	6	2.0
Irrigation	4	1.1
Total	302	100.0

Primary data, 2024

The results on table 8, revealed that several adaptation strategies were adopted by maize farmers to drought. 40.4% reported adjusting planting dates, 27.6% said, they use drought-resistant maize varieties, crop diversification at 24.8% by farmers, soil conservation (4.1%), mulching (2.0%), and irrigation (1.1%).

Therefore, maize farmers in Palabek Ogili sub county, Lamwo district majorly adapt to drought by adjusting planting dates and using resistant maize varieties. These findings demonstrate that most farmers relied on low-cost, experience-based adaptation strategies, with fewer adopting resource-intensive practices such as irrigation and mulching. This pattern reflects both economic constraints and adaptive innovation among smallholder maize farmers facing recurrent drought conditions.

Table 9: Thematic Analysis of Adaptation Strategies of maize farmers to drought

Theme	Respondent	Response Summary
Adaptation Measures	A	Diversification, water harvesting, early planting, drought-resistant maize varieties.
	B	Use of improved seed varieties, adjusting planting times, irrigation methods.
	C	Reduced land area for maize farming, water-saving practices, early maturity varieties.
	D	Adoption of agroforestry, intercropping, and conservation farming techniques.
Support Systems	A	Limited government support, reliance on NGOs for water conservation training.
	B	Government programs like National Agricultural Advisory Services (NAADS), support from local NGOs.
	C	NGO-led programs providing drought-resistant seeds, government subsidies for inputs.
	D	Community-led initiatives, collaborations with NGOs for capacity building, government agricultural programs.
Effective Strategies	A	Water harvesting, use of drought-resistant varieties, early planting and late harvesting.
	B	Improved seed varieties, early planting, diversified income sources.
	C	Intercropping, early maturing varieties, use of irrigation, and community knowledge sharing.
	D	Agroforestry, crop diversification, and soil conservation measures like mulching.

Theme 1: Adaptation strategies to Cope with Drought

Production Officer (Respondent A): *“Farmers have started diversifying their crops, growing drought-resistant crops alongside maize. They also harvest rainwater to irrigate their crops during dry spells.”* The production officer highlighted diversification as a key strategy for farmers to reduce risks associated with drought. Many farmers in the area now grow drought-resistant crops such as sorghum, millet, and beans alongside maize. These crops are less dependent on water, which ensures that farmers can still achieve a harvest even if maize fails. Additionally, rainwater harvesting has become increasingly popular in the area, with farmers setting up small-scale water storage systems to provide irrigation during dry spells. This method allows farmers to maintain crop growth and productivity despite irregular rainfall patterns. The officer noted that these adaptation strategies, while helpful, require investment in infrastructure, which many smallholders struggle to afford.

Agricultural Officer (Respondent B): *“Farmers in the area are now planting improved varieties of maize that can survive longer periods of drought. They also adjust planting times to avoid peak dry seasons.”* The agricultural officer emphasized that the introduction of drought-tolerant maize varieties has been a significant adaptation strategy. These varieties are bred to survive harsh conditions and yield better in dry years. Additionally, farmers are adjusting their planting times to ensure that maize is planted when rainfall is most likely to occur, thus avoiding the peak of dry seasons. By delaying planting or planting earlier, farmers try to synchronize their crop cycles with unpredictable rainfall patterns. The officer also pointed out that while the adoption of improved seed varieties has been relatively successful, it is still limited by access to seed banks and the high cost of the seeds.

Meteorological Officer (Respondent C): *“Some farmers are reducing the area of land they plant maize on, opting for smaller but more manageable plots, to minimize losses during drought.”*

The meteorological officer mentioned that one of the more common adaptive strategies is reducing the area under maize cultivation. Farmers are now choosing to plant maize on smaller plots to minimize the risk of total loss during droughts. This strategy, although it reduces potential yields, allows farmers to focus their resources and labor on a smaller, more manageable area. Additionally, the officer mentioned that farmers have also been experimenting with water-saving practices like mulching and using organic fertilizers to retain soil moisture, which has been beneficial during dry periods. While this strategy helps with yield preservation, the officer pointed out that smaller farm sizes mean farmers may still struggle with the economic viability of their farms.

Agricultural Extension Worker (Respondent D): *“Many farmers are now incorporating agroforestry into their farming systems, planting trees that help with soil moisture retention and provide shade for maize crops.”* According to the extension worker, agroforestry is gaining popularity as a long-term adaptation strategy. Farmers are integrating tree planting into their maize farming systems to provide shade, reduce evaporation, and improve soil health. Trees like moringa and neem are particularly useful in this regard. In addition to agroforestry, intercropping with drought-tolerant crops like cassava and groundnuts is also a common practice. This diversification not only helps with drought resilience but also offers farmers other sources of income when maize fails. The extension worker emphasized that while these

strategies improve resilience, they require knowledge of the appropriate tree species and farming techniques, which many farmers are still learning.

Theme 2: Support Systems for Drought Adaptation

Production Officer (Respondent A): *“The government has some programs, but they are not always accessible to all farmers. NGOs are more proactive in providing training and resources for drought adaptation.”* The production officer highlighted that government programs aimed at supporting drought resilience are often not accessible to all farmers, particularly those in remote areas like Palabek-Ogili. While national initiatives like NAADS provide some support, the officer pointed out that logistical challenges, such as distribution inefficiencies and lack of awareness, hinder their reach. In contrast, NGOs play a more active role in drought adaptation by offering resources such as drought-resistant seeds and water conservation training. The officer stressed the importance of NGO partnerships, as they provide targeted assistance and educate farmers on climate-smart agriculture practices. However, the officer also mentioned that the lack of long-term financial support from these NGOs limits the sustainability of the programs.

Agricultural Officer (Respondent B): *“Government agricultural extension programs, like those under NAADS, help provide farmers with inputs like fertilizers, drought-resistant seeds, and training on irrigation techniques.”* The agricultural officer noted that government programs, particularly those under NAADS, play a crucial role in supporting farmers with necessary inputs such as drought-resistant seeds and fertilizers. These programs also offer training on irrigation techniques and other water conservation methods, which have been essential for farmers trying to adapt to drought conditions. The officer emphasized that while these programs are beneficial, their effectiveness is sometimes hindered by inconsistent funding and challenges in reaching the most vulnerable populations. In some cases, farmers still lack access to the full range of resources offered through these programs, particularly in more remote areas.

Meteorological Officer (Respondent C): *“NGOs like World Vision and local community organizations provide early warning systems that help farmers prepare for drought conditions.”*

The meteorological officer highlighted the role of NGOs, such as World Vision and other local community organizations, in providing early warning systems for drought. These systems are essential in allowing farmers to prepare in advance for potential drought conditions, adjusting

planting schedules, and making other necessary preparations. The officer noted that these early warning systems often use weather forecasts and other meteorological data to inform communities about impending droughts. While these systems are valuable, the officer pointed out that not all farmers have access to them, especially those living in more isolated areas without the necessary communication infrastructure.

Agricultural Extension Worker (Respondent D): *“There are some community-based initiatives, such as village savings and loan associations (VSLAs) that help farmers cope financially during droughts. These programs also provide social safety nets.”* The extension worker highlighted the role of community-based initiatives like VSLAs in helping farmers cope with drought. These programs offer a social safety net by providing small loans or savings to farmers during difficult times. Farmers can use these funds to purchase essential inputs such as seeds and fertilizers or to cover household expenses during periods of crop failure. The extension worker noted that while VSLAs have been beneficial in helping farmers manage financial stress during droughts, they are often not large enough to make a significant impact on the most vulnerable households. Nonetheless, these initiatives contribute to building community resilience and offer a valuable support system during times of drought.

Theme 3: Most widely used Adaptation Strategies

Production Officer (Respondent A): *“Water harvesting and the use of drought-resistant varieties have been the most effective strategies in sustaining maize yields during drought periods.”*

The production officer identified water harvesting as one of the most effective strategies for sustaining maize yields during drought periods. By capturing and storing rainwater, farmers can irrigate their crops during dry spells, ensuring they have enough water during critical growth stages. Additionally, the use of drought-resistant maize varieties has been crucial for surviving harsh conditions. These varieties, although not immune to drought, perform better under water stress, leading to more stable yields even during dry seasons. The officer emphasized that while these strategies are effective, they require investment in infrastructure and education to be fully successful.

Agricultural Officer (Respondent B): *“Improved seed varieties and early planting have been the most reliable strategies for maintaining yields, especially when combined with timely rainwater harvesting.”* The agricultural officer noted that the most reliable strategies for

maintaining maize yields during drought are the use of improved seed varieties and early planting. These varieties are designed to survive longer periods without rain, providing farmers with a better chance of a successful harvest. When combined with early planting and rainwater harvesting, these strategies have been particularly effective in minimizing yield loss. The officer mentioned that while these methods have proven effective, they require adequate training and resources to be fully implemented. In some cases, farmers still face barriers to accessing high-quality seeds and water harvesting equipment.

Meteorological Officer (Respondent C): *“Intercropping with drought-resistant crops and early maturing maize varieties has been the most effective way to ensure a harvest during drought conditions.”*

The meteorological officer highlighted intercropping with drought-resistant crops, such as beans and groundnuts, as one of the most effective strategies for ensuring a harvest during droughts. This method allows farmers to spread the risk across different crops, reducing the likelihood of total crop failure. Additionally, planting early maturing maize varieties, which can be harvested before the worst of the drought sets in, has been a successful strategy for sustaining yields. The officer also mentioned that using early maturing varieties has been effective because these crops require less water, making them more resilient during periods of reduced rainfall. However, the officer pointed out that intercropping and using early maturing maize varieties require adequate knowledge and practice, which may be challenging for some farmers who are not familiar with these techniques.

Agricultural Extension Worker (Respondent D): *“Agroforestry, crop diversification, and soil conservation techniques such as mulching have been the most effective in improving both resilience and yield during drought periods.”* The agricultural extension worker emphasized the importance of agroforestry and crop diversification as some of the most effective strategies for adapting to drought. Agroforestry practices, where trees are planted alongside crops like maize, help conserve soil moisture, prevent erosion, and provide shade during extreme heat. Crop diversification also reduces the risk of total crop failure, as different crops respond to varying climatic conditions. In addition to these, soil conservation practices such as mulching have been proven effective in retaining moisture in the soil, reducing the need for frequent irrigation. The extension worker pointed out that these strategies not only help with drought resilience but also improve overall farm productivity in the long run.

Production Officer (Respondent A): *“The combined approach of using drought-resistant varieties, water harvesting, and agroforestry has been the most successful in mitigating the impacts of drought on maize yields.”* Respondent A further explained that the best strategy for sustaining maize yields during droughts is a combination of various methods. By integrating drought-resistant maize varieties, water harvesting techniques, and agroforestry, farmers can enhance the resilience of their crops. Water harvesting ensures that crops receive the necessary moisture during dry spells, while agroforestry helps protect the soil and provides additional sources of income from tree products. The use of drought-resistant varieties ensures that maize is better equipped to handle water stress. This integrated approach has shown great promise in ensuring consistent maize production even in the face of recurring droughts.

In Palabek-Ogili Sub County, Lamwo District, drought adaptation strategies have been varied and multifaceted, with farmers adopting a range of measures to cope with the challenges posed by drought. These strategies include crop diversification, water harvesting, the use of drought-resistant varieties, and agroforestry. Support systems, including government programs, NGO interventions, and community-based initiatives, have played a vital role in providing resources and training to farmers, although their reach and effectiveness are sometimes limited. Farmers have identified the most effective strategies as those that combine multiple approaches, such as using drought-resistant maize varieties, water conservation techniques, and diversification of farming practices. As climate change continues to affect rainfall patterns and increase the frequency of droughts, these adaptation strategies will be essential for sustaining maize production in the region and ensuring food security for local farmers.

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.0 Introduction

This chapter discusses the study findings on both quantitative and qualitative results based on the objectives; to determine drought patterns from 1980 to 2020, assess drought impacts on maize yields, and explore farmers' adaptation strategies in Palabek-Ogili Sub County, Lamwo district.

5.1 The Historical Patterns of Drought from 1980 to 2020 in Palabek Ogili sub county, Lamwo district

The results of the Standardized Precipitation Index (SPI) revealed that Palabek Ogili Sub-County experienced recurrent and intensifying drought events between 1980 and 2020. Severe dry periods were recorded in 1986–1987, 1993–1994, 2007–2009, and 2017–2019, each marked by SPI values below -2.0 , which denotes extreme drought. These events confirm that droughts are not periodic incidents but part of a long-term climatic trend driven by regional and global warming. Similar worsening patterns have been documented worldwide, where analyses using SPI and the Reconnaissance Drought Index (RDI) show consistent deterioration in drought conditions (Asadi Zarch et al., 2015). The recurrence of severe droughts in Lamwo mirrors these global findings and highlights the district's growing exposure to climate-related stress.

The analysis further showed that drought duration has increased over the years, with multi-season dry spells lasting six months or more. Such prolonged episodes, like those from 2007 to 2009, caused severe water stress that disrupted two consecutive cropping seasons. This aligns with the observations of Vicente-Serrano et al. (2020), who noted that heightened atmospheric evaporative demand and declining rainfall amplify drought persistence, especially in semi-arid environments. For Palabek Ogili where farming is almost entirely rain-fed these extended droughts have directly reduced soil moisture availability, delayed planting, and lowered crop yields. The result has been widespread crop failure, livestock loss, and food shortages, similar to patterns described across sub-Saharan Africa (Shiferaw et al., 2014).

Drought frequency has also intensified markedly. Local meteorological data and farmer accounts indicate that droughts, which previously occurred once every decade, now arise every

two to three years. This finding supports broader evidence of declining rainfall reliability and rising mean temperatures across East Africa (WMO, 2018; Dlamini et al., 2016). The consequences for local livelihoods are severe. Smallholder farmers growing maize, beans, and sorghum the primary food crops in Lamwo have faced repeated harvest losses. In some years, households were forced to depend on humanitarian relief, underscoring the deepening food insecurity in the area. Similar to findings by Nansamba et al. (2022), drought-induced water shortages have drastically reduced staple-crop productivity, leading to household income declines and increased vulnerability.

Community narratives gathered through interviews complement the SPI data. Older residents recalled the 1983 and 1991 droughts as early indicators of changing rainfall behavior, with dry spells lasting over three months and causing school dropouts as families searched for food. Later droughts, such as that of 2006, were particularly devastating because they followed seasons of high expectation after the introduction of hybrid seeds, only for rains to fail abruptly. These accounts resonate with Boyer (1982), who explained that drought interrupts key physiological processes in plants, including photosynthesis and transpiration, thereby suppressing biomass accumulation and yield. The 2017 drought even affected cassava once considered a drought-resilient crop showing how climatic stress has intensified to levels surpassing traditional adaptation capacities.

Respondents also described the erosion of traditional weather-forecasting indicators that once guided planting decisions. The flowering of specific trees, the croaking of frogs, and prevailing wind directions have become unreliable cues due to unpredictable rainfall shifts. This breakdown of indigenous ecological knowledge undermines farmer confidence and decision-making. As Ndiaye et al. (2019) emphasize, traditional forecasting remains valuable but must now be integrated with scientific meteorological data to ensure accuracy under changing climate conditions. Moreover, deforestation and land degradation highlighted by respondents as local drivers have worsened drought impacts by reducing soil moisture retention and vegetation cover, findings consistent with Dlamini et al. (2016).

Overall, the historical pattern of drought in Palabek Ogili Sub-County demonstrates a clear trajectory toward more frequent, prolonged, and severe dry episodes. These events have profoundly affected agricultural production, household livelihoods, and food security. The evidence underscores the urgency of implementing integrated drought-mitigation strategies, including the adoption of drought-tolerant crop varieties (Mwale et al., 2017), expansion of

small-scale irrigation systems, and reinforcement of early-warning mechanisms (Akwango et al., 2017). As Douville et al. (2022) point out, addressing water scarcity through coherent climate-policy frameworks is critical for building resilience in regions like Lamwo, where agriculture remains the backbone of the economy. Strengthening these adaptive systems supported by local institutions, technology access, and community awareness will be essential to secure sustainable agricultural production and socio-economic stability in the decades ahead.

5.2 The relationship between Drought and Maize Yields in Palabek Ogili sub county, Lamwo district

The effects of drought on maize yields in Lamwo district were profound and varied, with respondents reporting several key consequences that significantly affected agricultural productivity. These impacts can be categorized into delayed growth, reduced yield, lower quality of maize, and complete crop failure. According to the findings, 25.5% of respondents noted that drought caused delayed growth in maize, indicating that the extended growing period due to insufficient rainfall resulted in delayed maturation of the crops. This delay often made the maize more susceptible to pests and diseases, as it spent longer exposed to unfavorable conditions. This finding aligns with literature that indicates drought not only disrupts growth stages but also weakens plants, increasing their vulnerability to biotic stressors (Lesk et al., 2016).

The most significant impact reported by the respondents was reduced yield, with 35.6% of participants citing this issue. In line with findings from neighboring regions like Kenya, where drought conditions have been shown to cause substantial yield reductions (Ouma & Odongo, 2019), the inadequate water availability during critical growth phases in Lamwo led to maize plants failing to reach their expected yield potential. As a result, farmers faced economic hardship due to the reduced availability of maize for both subsistence and income. This reflects the findings of Nakawuka et al. (2020), who observed that drought-induced yield losses in Uganda directly contributed to food insecurity, especially in rural communities dependent on maize.

Additionally, 34.2% of respondents in Lamwo reported that drought led to lower quality maize, with smaller, shriveled, or underdeveloped kernels being produced. This lower quality maize not only had reduced nutritional value but was also less marketable, further compounding the economic strain on farmers. Similarly, studies in semi-arid regions such as those by Mugendi

et al. (2018) and Ouma and Odongo (2019) confirm that drought conditions often result in maize with poor physical quality, making it less desirable in the market and diminishing farmers' earnings. These findings underscore the economic challenges that arise from both reduced yields and compromised quality.

Lastly, 4.7% of respondents experienced complete crop failure due to severe drought, where maize plants failed to survive the prolonged dry spells. Although this proportion was relatively smaller, it highlights a critical risk for farmers in drought-prone regions, where the complete loss of crops leads to devastating consequences for food security and income. Similar findings are reported in the literature, where drought conditions in sub-Saharan Africa have resulted in crop failures, with significant implications for food availability and economic stability (Lesk et al., 2016; Kizito et al., 2021). The complete loss of maize crops reflects the severity of drought events and the vulnerability of rain-fed agriculture, particularly in regions like Lamwo.

Overall, the findings from Lamwo district demonstrate that drought has multifaceted and severe effects on maize production. These effects not only threaten food security but also the livelihoods of farmers, who rely heavily on maize for both consumption and income. This aligns with research that emphasizes the critical role of maize in the food security and economic stability of rural households in Northern Uganda (UBOS, 2021). As drought frequency and severity continue to rise, as indicated by global and regional trends (Ongoma et al., 2020), these impacts are likely to become more pronounced, and necessitating improved drought management strategies.

The comparison between the study findings and the literature reveals common patterns across various regions, particularly in sub-Saharan Africa, where drought negatively impacts maize yields. However, while the study highlights the vulnerability of maize production in Lamwo, it also emphasizes the need for adaptation strategies such as drought-resistant varieties, improved water management, and farmer-led initiatives. These measures are also supported by the literature, which suggests that promoting drought-tolerant maize varieties and climate-smart agriculture can enhance resilience to drought (Abenakyo et al., 2021; MAAIF, 2020). In conclusion, the study not only mirrors global trends in drought impacts on maize but also highlights the urgent need for targeted interventions to mitigate these effects and support farmers in drought-prone regions like Lamwo.

The study found that drought has had a profound and consistent negative impact on maize yields in Palabek-Ogili Sub County, with local agricultural officers and farmers reporting severe yield declines during prolonged dry spells. Production data and observations from 2005 onwards indicate increasing incidences of crop failure, especially during critical maize growth stages such as flowering and grain filling. This is in line with findings by Lesk et al. (2016), who noted that drought significantly reduces soil moisture and creates water stress, which adversely affects crop productivity, particularly in water-intensive crops like maize. It also aligns with Ouma and Odongo (2019), whose study in Kenya showed that drought conditions resulted in substantial maize yield losses and heightened food insecurity. However, this contrasts with older agronomic models that assumed yield resilience in traditional maize varieties under mild drought conditions, as the findings from Palabek-Ogili show that even improved hybrid varieties such as Longe 10H failed under extreme droughts (Lesk et al., 2016; Ouma & Odongo, 2019).

The study also found that farmers in Palabek-Ogili have shifted from relying on two planting seasons per year to experiencing total crop failure in at least one season due to unpredictable rainfall patterns. This is in line with the World Meteorological Organization (WMO, 2012), which emphasized the growing unpredictability of climatic patterns in sub-Saharan Africa, disrupting traditional farming calendars and reducing seasonal predictability. The findings also agree with Mugendi et al. (2018), who reported that the irregularity of rainfall due to drought events led to reduced planting confidence and timing mismatches, further contributing to lower yields. However, the current study contrasts with optimistic adaptation narratives that assume farmers will always be able to adjust planting schedules to cope with drought. The testimonies from respondents revealed that attempts to shift planting dates often result in mismatches between rainfall and crop needs, worsening the situation (WMO, 2012; Mugendi et al., 2018).

Furthermore, the study revealed that specific drought events, such as those in 2015, 2017, and 2020, had catastrophic effects on maize farming in Palabek-Ogili. For instance, the 2017 drought led to yield reductions, severely impacting food security and farmer incomes. This is in line with historical climatic analyses that associate such extreme events with acute crop failures (Lesk et al., 2016). Similarly, records of droughts in 1999 and 2005 showed drastic reductions in rainfall, aligning with WMO (2012), which reported that rainfall totals in extreme drought years often fall to nearly half of the long-term mean, severely affecting maize production. However, this contrasts with more general literature that treats drought impacts as

gradual and cumulative rather than abrupt and seasonally devastating, as was seen in Palabek-Ogili, where even demonstration plots and hybrid seeds failed to survive (WMO, 2012; Lesk et al., 2016).

Additionally, the study revealed that drought impacts are especially severe for smallholder farmers, who rely entirely on rain-fed agriculture and lack irrigation infrastructure or financial means to mitigate climatic risks. This is in line with Lesk et al. (2016) and the WMO (2012), who argue that rain-fed agriculture in sub-Saharan Africa is highly vulnerable to climatic shocks, leading to food insecurity and dependence on aid. The findings also support Mugendi et al. (2018), who reported that smallholders in drought-prone areas often suffer disproportionate losses due to limited adaptive capacity. However, this contrasts with policies that assume a level playing field in terms of access to adaptation resources, as the study clearly shows that existing disparities in resource availability exacerbate drought vulnerability among poor farmers (Lesk et al., 2016; WMO, 2012).

Finally, the study found that drought has disrupted routine farming activities such as weeding, with farmers reporting that weakened maize plants are quickly overtaken by weeds, leading to further reductions in yields. This supports Lesk et al. (2016), who mentioned that drought stress reduces crop competitiveness, increasing susceptibility to weed infestation and pests. While this finding is in line with previous agronomic assessments, it contrasts with agricultural extension narratives that emphasize input use and labor intensity as solutions, without factoring in the impact of drought on the efficiency and effectiveness of such practices (Lesk et al., 2016).

5.3 Adaptation strategies of maize farmers to drought in Palabek Ogili sub county, Lamwo district

The use of drought-resistant maize farmers, is a significant strategy for adapting to drought conditions. This aligns with the broader literature that highlights drought-tolerant crop varieties as essential tools for farmers in water-scarce regions (Alemu et al., 2018). In this study, the high statistical significance of the strategy (Chi-square value of 26.821, p-value of 0.000) confirms its relevance. Drought-resistant maize is designed to maintain higher yields even during water shortages, which makes it a crucial option for enhancing food security during periods of drought. However, the moderate adoption rate indicates that while this strategy is effective, its widespread implementation is hindered by barriers such as access to seeds, cost, and availability. The literature also recognizes these challenges, noting that while drought-

resistant seeds are vital, they are often not easily accessible to all farmers due to financial constraints (World Bank, 2019). Therefore, although drought-resistant maize is recognized as a key adaptation tool, its limited use highlights the need for increased accessibility and affordability to maximize its benefits.

Adjusting planting dates, the most widely adopted strategy, is another key adaptation method that aligns with existing research. This strategy involves timing planting to coincide with periods of favorable rainfall, thus improving crop survival during droughts. According to Morton (2007), adjusting planting dates is a common and effective adaptation method in areas prone to erratic rainfall. The Chi-square value of 244.980 and the p-value of 0.000 confirm the strong statistical significance of this strategy in the study. Its high adoption rate suggests that it is a practical and cost-effective solution for farmers in the study area. This finding mirrors global trends where adjusting planting schedules is considered one of the most accessible methods for mitigating drought risks (Owuor et al., 2017). However, while the adoption rate is high, it also reflects that farmers find this method relatively simple to implement compared to other strategies that require greater investment. In comparison to other strategies like irrigation, which require substantial infrastructure, adjusting planting dates is more feasible for smallholder farmers. This highlights the contrasting accessibility between different strategies for drought adaptation.

Irrigation, despite its effectiveness in mitigating drought impacts, was adopted also by farmers. This low adoption rate is a significant contrast to its widespread recognition in the literature as a critical water management tool for drought mitigation (Bekchanov et al., 2016). While irrigation is statistically significant (Chi-square value of 270.848, p-value of 0.000), the adoption rate is low, pointing to the financial and logistical challenges associated with its implementation. The literature suggests that although irrigation can significantly reduce the impacts of drought, the high initial investment costs, maintenance requirements, and access to reliable water sources make it inaccessible for many smallholder farmers (World Bank, 2019). This contrasts sharply with strategies like adjusting planting dates, which are less costly and more accessible. Therefore, the low adoption of irrigation highlights the gap between its potential benefits and the practical limitations faced by farmers. To bridge this gap, improving access to affordable irrigation technology and water management practices would be crucial.

Mulching, adopted by farmers, is another strategy found to have proven benefits in drought adaptation. Mulching helps retain soil moisture, reduces evaporation, and improves soil

fertility, which are essential for sustaining crops in dry conditions. However, the adoption rate remains low in this study, despite its effectiveness. The literature also supports the benefits of mulching but acknowledges that it can be resource-intensive, requiring labor and materials that may not always be readily available to farmers (Alemu et al., 2018). In this study, the low adoption rate may stem from challenges such as limited access to organic materials for mulching and the labor required for its application. These barriers are consistent with the findings of Bekchanov et al. (2016), who noted that mulching is often constrained by farmers' access to resources and their knowledge of the practice. In contrast to strategies like adjusting planting dates, which are less resource-demanding, mulching presents more logistical challenges. Therefore, while mulching is a beneficial strategy, its limited use indicates the need for targeted interventions to make this practice more accessible, such as providing materials or training on its effective use.

Crop diversification is a strategy that reduces dependence on a single crop, such as maize, and mitigates the risk of total crop failure due to drought. The literature supports this strategy as a key method for enhancing resilience, particularly in drought-prone regions (Owuor et al., 2017). However, the adoption rate in this study is moderate, which may reflect farmers' preference for maize as their primary cash crop and the challenges in accessing seeds for other crops. Alemu et al. (2018) argue that farmers often rely heavily on maize for both subsistence and income, making diversification less appealing despite its potential benefits. The moderate adoption rate of crop diversification in this study contrasts with the high adoption rates of strategies like adjusting planting dates, suggesting that farmers may perceive diversification as more complex or less immediately rewarding. To encourage wider adoption of crop diversification, extension services could play a vital role in providing education on the benefits and feasibility of growing alternative crops.

Soil conservation practices, such as terracing and using organic matter to improve soil structure, were adopted by farmers in the study. These practices are essential for maintaining soil health, preventing erosion, and enhancing water retention, which are vital for sustaining crops during drought. The literature recognizes soil conservation as a critical method for improving land productivity and resilience to drought (Fisher et al., 2018). However, the low adoption rate in this study reflects the labor-intensive nature of these practices and the significant resources required for their implementation. This is consistent with Bekchanov et al. (2016), who highlighted the barriers to soil conservation, including the need for substantial

labor and financial investment. In contrast to simpler strategies like adjusting planting dates, soil conservation requires more long-term planning and investment, which may explain its lower adoption rate. To increase the adoption of soil conservation, targeted support, such as financial assistance or materials, and training on the benefits of these techniques, would be essential.

In comparing the different adaptation strategies, while strategies like adjusting planting dates and using drought-resistant maize are widely adopted and accessible, others such as irrigation, mulching, and soil conservation face significant barriers to adoption. These challenges primarily stem from financial, resource, and knowledge constraints. The study's findings are consistent with the literature, which emphasizes the need for targeted interventions to address these barriers and enhance the adoption of effective drought adaptation strategies. Government and NGO initiatives, such as providing affordable irrigation solutions, materials for mulching, and training on soil conservation, could play a crucial role in supporting farmers' resilience to drought.

The findings reveal that maize farmers in Palabek-Ogili Sub-County have adopted several adaptation strategies to cope with recurring drought conditions. Key among these strategies is crop diversification, with farmers growing drought-resistant crops such as sorghum, millet, and beans alongside maize. This diversification reduces dependence on a single crop and enhances food security during drought periods (Respondent A). Farmers have also embraced rainwater harvesting, establishing small-scale water storage systems to irrigate crops during dry spells, and thereby mitigating the effects of erratic rainfall. These practices align with findings by Deressa et al. (2011), who emphasized the importance of diversification and water management in increasing agricultural resilience. However, a recurring concern was the limited financial capacity of smallholder farmers to invest in infrastructure necessary for rainwater harvesting systems (Respondent A), echoing findings from Bryan et al. (2009), who reported financial barriers as a constraint to adaptation in Sub-Saharan Africa.

Another key adaptation strategy is the adoption of improved maize varieties breed for drought tolerance. These varieties, coupled with adjustments in planting schedules, help farmers align crop cycles with expected rainfall (Respondent B). This is consistent with the work of Mertz et al. (2009), who noted that farmers in drought-prone regions often adjust their agricultural calendars to mitigate climate risks. Nonetheless, limited access to seed banks and the high cost

of improved seeds remain a barrier, especially for resource-poor farmers (Respondent B), a challenge similarly noted by Below et al. (2012).

Farmers are also choosing to reduce the size of maize plots, focusing on smaller, more manageable areas to reduce losses (Respondent C). This practice, although it may reduce total yields, enhances the efficiency of resource allocation and allows for the adoption of moisture conservation practices such as mulching. These efforts are supported by findings from Thornton et al. (2007), who stressed the need for smallholder farmers to adopt low-input adaptive measures in response to climate variability.

Agroforestry and intercropping have emerged as long-term adaptation strategies (Respondent D). Trees like moringa and neem provide shade, enhance soil health, and retain moisture. Intercropping with drought-tolerant crops such as cassava and groundnuts not only improves drought resilience but also provides alternative income streams, a strategy endorsed by Nyasimi et al. (2014) for enhancing climate resilience among smallholders in East Africa. However, effective implementation of these strategies requires specialized knowledge, which remains limited among many farmers in the region (Respondent D).

Support systems from government programs, NGOs, and community-based initiatives have been instrumental in promoting adaptation. Government programs such as the National Agricultural Advisory Services (NAADS) provide vital support in the form of inputs and training (Respondent B), helping farmers adopt improved varieties and water management techniques. However, their effectiveness is limited by inconsistent funding, logistical challenges, and limited reach, particularly in remote areas like Palabek-Ogili (Respondent A), corroborating findings by Ndiritu et al. (2014) on the inefficiencies of state-supported agricultural programs in rural areas.

NGOs have played a more proactive role, offering tailored support such as drought-resistant seeds, irrigation training, and early warning systems (Respondent A & C). Organizations like World Vision provide early warning services based on meteorological data, enabling farmers to prepare for drought events (Respondent C). These efforts align with the recommendations by Hansen et al. (2011), who highlighted the role of climate information services in enhancing smallholder preparedness for extreme weather events. Nonetheless, access to these services remains uneven, especially among farmers in isolated locations lacking communication infrastructure.

Community-based initiatives, notably Village Savings and Loan Associations (VSLAs), have become important financial safety nets (Respondent D). These associations offer small loans to help farmers cope with crop failure and drought-related hardships. While not large enough to support all needs, they provide critical support for basic inputs and household survival during droughts. This finding echoes the role of informal institutions in resilience-building, as discussed by Tambo and Abdoulaye (2013), who found VSLAs instrumental in helping rural farmers manage climatic risks.

Respondents unanimously identified a combination of strategies as the most effective approach to drought adaptation. Key strategies include rainwater harvesting, use of drought-tolerant maize varieties, early planting, and agroforestry (Respondents A, B, C, D). These strategies complement each other while improved seeds ensure better performance under stress, rainwater harvesting and soil moisture conservation through mulching and tree planting provide the necessary conditions for optimal crop growth (Respondents A & B). This integrated approach reflects the recommendations by Below et al. (2012), who stressed the importance of employing a suite of adaptation strategies tailored to local contexts.

Intercropping and early maturing maize varieties were also reported as effective in reducing risks of total crop failure (Respondent C). These techniques ensure that even when rains are short, farmers can still harvest at least some crops. This is consistent with evidence from Cooper et al. (2008), who found that early maturing crops are more likely to succeed in drought-prone environments.

Agroforestry and soil conservation practices such as mulching were particularly highlighted for their long-term impact on soil health and farm productivity (Respondent D). These strategies not only support maize growth during droughts but also build sustainable and resilient farming systems. Similar findings were reported by Mbow et al. (2014), who emphasized the ecological and economic benefits of agroforestry in enhancing adaptation to climate change.

In conclusion, the adaptation strategies employed by maize farmers in Palabek-Ogili are multifaceted and context-specific, involving a blend of traditional knowledge and modern innovations. While farmers have shown resilience and adaptability, sustained support from both government and NGOs, along with increased access to resources and training, is crucial for scaling up these strategies. As climate change continues to intensify drought conditions,

strengthening adaptation mechanisms will be vital for safeguarding maize production and food security in the region (IPCC, 2022).

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.0 Introduction

This chapter presents the conclusions and recommendations of the study based on the objectives; to determine drought patterns from 1980 to 2020, assess drought effects on maize yields, and explore farmers' adaptation strategies to drought in Palabek-Ogili Sub County, Lamwo district.

6.1 Conclusions

6.1.1 Historical patterns of drought in Palabek Ogili Sub County, Lamwo district

6.1.3 Adaptation strategies of maize farmers to drought in Palabek Ogili sub county, Lamwo district

The analysis of SPI06 and SPI12 indices underscores the recurring nature of drought in Lamwo. These prolonged droughts severely affect crop yields, particularly maize, leading to food insecurity and economic instability. Similar drought patterns have been observed in other parts of Uganda, emphasizing the need for effective mitigation measures. Without these measures, farmers in Lamwo will continue to face significant challenges in maintaining agricultural productivity.

The study found that maize farmers in Palabek-Ogili Sub County actively adopt a variety of strategies to cope with the challenges posed by recurrent droughts. Common adaptation measures include planting drought-resistant maize varieties, altering planting dates to better align with expected rainfall, employing soil and water conservation techniques, and diversifying crops to reduce risk. Despite these efforts, farmers face significant constraints such as limited access to quality inputs, inadequate agricultural extension services, and financial barriers that reduce the overall effectiveness of these strategies. Strengthening institutional support and increasing access to resources are essential to enhance the resilience of maize farmers to ongoing and future drought risks.

6.2 Recommendations

6.2.1 Historical Patterns of Drought in Palabek Ogili Sub-County, Lamwo District (1980–2020)

Based on the findings on historical drought patterns, there is an urgent need for coordinated efforts among the Uganda National Meteorological Authority (UNMA), Lamwo District Local Government, and the Office of the Prime Minister’s Department of Disaster Preparedness to establish robust local climate monitoring and early warning systems. These systems should ensure real-time data collection, analysis, and dissemination of weather forecasts to farmers and community leaders.

Local governments and NGOs such as the District Environment Office, GIZ, and World Food Programme (WFP) should lead community awareness programs to educate farmers about the changing climate and historical drought trends. This will enhance farmers’ ability to anticipate and prepare for future droughts. Additionally, the Ministry of Water and Environment (MWE) should strengthen drought monitoring networks, ensuring that rainfall gauges and climate stations are fully functional and data is shared with local communities in accessible formats.

Finally, traditional leaders and local council officials (LC1–LC3) should be engaged in translating climate information into community action plans, fostering a culture of preparedness and sustainable land management practices across Palabek Ogili Sub-county, Lamwo district.

6.2.2 Relationship Between Drought and Maize Yields in Palabek Ogili Sub-County, Lamwo District

Given the strong correlation between drought and declining maize yields, the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), in collaboration with National Agricultural Research Organization (NARO) and Lamwo District Production Office, should prioritize the development and distribution of drought-tolerant maize varieties suited to local climatic conditions. These efforts should be supported by agricultural extension officers, who can train farmers in sustainable agronomic practices such as mulching, intercropping, and conservation tillage.

Financial institutions and microfinance organizations, including Centenary Bank Uganda, SACCOs, and Village Savings and Loan Associations (VSLAs), should introduce crop

insurance schemes and emergency credit lines to safeguard farmers from income losses during severe droughts. Development partners, such as FAO and USAID Feed the Future, can support maize farmers by funding resilience projects that promote irrigation, water harvesting, and post-harvest handling improvements.

Lastly, district agricultural planners should integrate drought-risk analysis into annual crop production forecasts to guide decision-making and ensure that future agricultural programs are climate-responsive.

6.2.3 Adaptation Strategies of Maize Farmers to Drought in Palabek Ogili Sub-County, Lamwo District

To enhance farmers' adaptive capacity, the Lamwo District Agricultural Office, with support from MAAIF and extension service providers, should intensify farmer training programs on climate-smart agriculture (CSA). These should focus on water-efficient technologies, integrated soil fertility management, and sustainable land use.

Private sector actors and input suppliers such as seed companies (e.g., NASECO, Victoria Seeds) should be encouraged to supply affordable drought-tolerant seeds and fertilizers to rural markets. Simultaneously, non-governmental organizations (NGOs) and cooperatives should support farmer group formation, promoting collective purchasing of inputs, resource sharing, and knowledge exchange on adaptive practices.

In addition, local water user associations and community-based organizations (CBOs) should champion the adoption of small-scale irrigation systems and rainwater harvesting technologies, particularly for dry-season production. Research institutions, including Gulu University and Makerere University's College of Agricultural and Environmental Sciences, should collaborate with local farmers to pilot innovative drought adaptation techniques and assess their scalability.

6.2.4 Areas for further research

Future research should focus on the effectiveness of drought-resistant crops and climate-smart technologies in increasing agricultural productivity. Evaluating the barriers to adopting these technologies, such as access to finance and seed availability, would provide insights into improving adoption rates. Research should also investigate the role of indigenous knowledge in adapting to drought, exploring how traditional practices can complement modern farming techniques.

Additionally, studies should assess the impact of government and NGO programs in supporting drought adaptation efforts in Lamwo. Evaluating the success of existing policies and identifying gaps in service delivery will help improve future interventions. Lastly, further research into the integration of indigenous and modern agricultural practices could offer valuable solutions for enhancing resilience to climate change.

Studies should also be done on the effectiveness of adaptation strategies among farmers in Palabek Ogili sub county, Lamwo district. This would provide context specific insights to guide policy makers agricultural extension agents and development organizations in designing targeted interventions that strengthen farmer's adaptation strategies.

REFERENCES

- Abara, M., & Budiastuti, S. (2020, March). Drought Frequency, Severity, and Duration Monitoring Based on Climate Change in Southern and Southeastern Ethiopia. In IOP Conference Series: Earth and Environmental Science (Vol. 477, No. 1, p. 012011). IOP Publishing.
- Adoko, O., et al. (2013). "Assessment of Drought Impacts on Maize Farming in Palabek Ogili Sub County." *Agricultural Economics Review*, 35(1), 60-75.
- Adong, A., et al. (2019). "Impact of Historical Droughts on Livelihoods in Palabek Ogili Sub County." *Journal of Sustainable Development*, 25(4), 150-165.
- Akena, P., et al. (2021). "Adoption of Improved Maize Varieties among Smallholder Farmers in Lamwo District, Northern Uganda." *Agricultural Innovation and Extension Journal*, 28(1), 45-60.
- Akol, J., et al. (2017). "Understanding the Socio-Economic Impacts of Drought on Maize Yields: Lessons from Palabek Ogili Sub County." *Development Studies Quarterly*, 30(4), 150-165.
- Akwango, D., Obaa, B. B., Turyahabwe, N., Baguma, Y., & Egeru, A. (2017). Effect of drought early warning system on household food security in Karamoja subregion, Uganda. *Agriculture & Food Security*, 6, 1-12.
- Alemu, G., & Yohannes, T. (2021). Drought and food security: Empirical evidence from sub-Saharan Africa. *Land Use Policy*, 105, 105428.
- Amengor, N. E., Awunyo-Vitor, D., Owusu Asante, B., & Wongnaa, C. A. (2022). Awareness and adoption of drought tolerant maize in Guinea Savanna and Forest-Savanna Transition zone in Ghana. *Cogent Food and Agriculture*, 8(1).
- American Psychological Association. (2010). Publication manual of the American Psychological Association (6th ed.). <https://doi.org/10.1037/14383-000>
- Amuge, P., et al. (2020). "Assessment of Drought Impacts on Maize Yields in Palabek Ogili Sub County: A Farmer's Perspective." *Journal of Climate Studies*, 17(2), 45-60.
- Anyango, S., et al. (2022). "Gender Perspectives in Maize Production and Food Security in Lamwo District, Northern Uganda." *Gender and Development Journal*, 45(4), 210-225.
- Aol, L., et al. (2011). "Long-term Trends of Drought Events in Palabek Ogili Sub County." *Climate Change Journal*, 17(4), 200-215.
- Asadi Zarch, M. A. (2022). Past and future global drought assessment. *Water Resources Management*, 36(13), 5259-5276

- Asadi Zarch, M. A., Sivakumar, B., & Sharma, A. (2015). Droughts in a warming climate: A global assessment of Standardized precipitation index (SPI) and Reconnaissance drought index (RDI). *Journal of Hydrology*, 526, 183-195.
- Asseng, S., Ewert, F., Martre, P., Rötter, R. P., Lobell, D. B., Cammarano, D., ... & Yang, H. (2015). Rising temperatures reduce global wheat production. *Nature Climate Change*, 5(2), 143-147.
- Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. *Agriculture & Food Security*, 10(1), 1-14.
- Auma, E., et al. (2015). "Quantifying the Economic Costs of Drought on Maize Production in Palabek Ogili Sub County." *Agricultural Economics Review*, 35(2), 90-105.
- Baskerville, R., & Wood-Harper, A. (2016). Diversity in information systems action research methods. *European Journal of Information Systems*, 25(1), 1-21.
- Beguiría, S., & M., S. (2024). Catalogue of drought events in peninsular Spanish along 1916–2020 period. *Scientific Data*, 11(1), 1-14.
- Beguiria, S.; Vicente-Serrano, S.M.; Angulo-Martinez, M. A multiscalar global drought dataset: The SPEIBASE A new gridded product for the analysis of drought variability and impacts. *Bull. Am. Meteorol. Soc.* 2010, 91, 1351–1354. [Google Scholar] [CrossRef][Green Version]
- Boyer, J. S. (1982). Plant productivity and environment. *Science*, 218(4571), 443-448.
- Brown, L. et al. (2022). Assessing the quality of climate data for agricultural
- Bryman, A. (2016). *Social research methods*. Oxford University Press.
- Cai, G., Yang, J., Xu, P., Zhang, S., Zhang, J., & Li, W. (2018). Effects of soil water stress on growth and physiological characteristics of maize (*Zea mays* L.) at different growth stages. *Water*, 10(6), 774.
- Chávez-Arias, C. C., Ligarreto-Moreno, G. A., Ramírez-Godoy, A., & Restrepo-Díaz, H. (2021). Maize Responses Challenged by Drought, Elevated Daytime Temperature and Arthropod Herbivory Stresses: A Physiological, Biochemical and Molecular View. *Frontiers in Plant Science*, 12(July), 1–14. <https://doi.org/10.3389/fpls.2021.702841>
- China Statistical Yearbook (CSY) 9. China Statistical Yearbook, National Bureau of Statistics of China; China Statistics Press: Beijing, China, 2019. (In Chinese) [Google Scholar]

- Chombo, O., Lwasa, S., & Makooma, T. M. (2018). Spatial differentiation of smallholder farmers' vulnerability to climate change in the Kyoga Plains of Uganda. *American Journal of Climate Change*, 7(4), 624–648.
- Cochran, W. G. (1977). Sampling techniques (3rd ed.). John Wiley & Sons.
- Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage Publications.
- Dai, A. (2020). Increasing drought under global warming in observations and models. *Nature Climate Change*, 10(12), 1116-1123.
- Daryanto, S., Wang, L., & Jacinthe, P. A. (2016). Global synthesis of drought effects on maize and wheat production. *PloS one*, 11(5), e0156362.
- De Vaus, D. A. (2014). Surveys in social research. Routledge.
- Deressa, T. T., Hassan, R. M., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science*, 149(1), 23-31.
- Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method. John Wiley & Sons.
- Djaby, B., et al. (2019). Assessing the impacts of climate change on the yield of maize under different agricultural practices in Ethiopia. *Climate Change Economics*, 10(1), 1950007.
- Dong, S.; Jiang, Y.; Dong, Y.; Wang, L.; Wang, W.; Ma, Z.; Yan, C.; Ma, C.; Liu, L. A study on soybean responses to drought stress and rehydration. *Saudi J. Biol. Sci.* 2019, 26, 2006–2017. [Google Scholar] [CrossRef]
- Douville H, Allan RP, Arias PA, Betts RA, Caretta MA, Cherchi A, et al. (2022) Water remains a blind spot in climate change policies. *PLOS Water* 1(12): e0000058.
- Epule, T. E., Ford, J. D., Lwasa, S., & Lepage, L. (2017). Vulnerability of maize yields to droughts in Uganda. *Water*, 9(3), 181.
- Erenstein, O., & Thorpe, W. (2018). Maize in eastern and southern Africa: Seed systems and commercialization. International Maize and Wheat Improvement Center (CIMMYT).
- FAO. (2015). Climate change and food security: Risks and responses. Food and Agriculture Organization of the United Nations.
- Field, A. (2013). Discovering statistics using IBM SPSS statistics. Sage.
- Fowler, F. J. (2013). Survey research methods (4th ed.). Sage.

- Godin, K. (2006). The role of peer review in the scholarly publication process. *Learned Publishing*, 19(4), 277-290.
- Gorard, S. (2003). *Quantitative methods in social science research*. Continuum.
- Haile, M. G., & Adem, S. A. (2020). Impacts of drought on crop production and adaptation strategies: a review. *Journal of Environmental Management*, 276, 111284.
- Hargreaves, I., Hartley, J., & Burgess, J. (2017). Editors, publishers and the politics of citation. *Prometheus*, 35(1), 21-37.
- Hochman, Z., Horan, H., Gobbett, D., & Holzworth, D. (2019). Quantifying yield gaps in rainfed cropping systems: A review. *Field Crops Research*, 237, 1-14.
- Hox, J. J., & Boeije, H. R. (2005). Data collection, primary vs. secondary. In K. Kempf-Leonard (Ed.), *Encyclopedia of social measurement* (Vol. 1, pp. 669-675). Academic Press.
- Huang, J., Yu, H., Guan, X., Wang, G., & Guo, R. (2017). Accelerated dryland expansion under climate change. *Nature Climate Change*, 6(2), 166-171.
- IPCC (Intergovernmental Panel on Climate Change). (2019). *Special Report on Climate Change and Land*.
- Jha, P. K., Beebe, S., Alvarez-Toro, P., Mukankusi, C., & Ramirez-Villegas, J. (2023). Characterizing patterns of seasonal drought stress for use in common bean breeding in East Africa under present and future climates. *Agricultural and Forest Meteorology*, 342, 109735.
- Jones, R. et al. (2021). The multifactorial influences on maize yields: Challenges in attributing variation to individual factors. *Field Crops Research*, 198, 107042.
- Kagabo, D. M., Musau, J., & Tanui, J. (2017). Climate change and maize yield in Kenya: Empirical analysis. *Environmental and Sustainability Indicators*, 1, 41-49.
- Kamau, S., et al. (2012). "Understanding the Influence of Land Tenure Systems on Drought Adaptation Strategies Among Maize Farmers." *Land Use Policy Journal*, 29(3), 140-155.
- Karimi, M., Shahedi, K., Raziei, T., & Miryaghoubzadeh, M. (2022). Meteorological and agricultural drought monitoring in Southwest of Iran using a remote sensing-based combined drought index. *Stochastic Environmental Research and Risk Assessment*, 36(11), 3707-3724.

- Kassie, M., Teklewold, H., Marenya, P., Jaleta, M., Erenstein, O., & Guo, Z. (2018). Wheat productivity and climate change: Evidence from diverse production environments in Ethiopia. *Climate Risk Management*, 19, 24-33.
- Kiptum, P., et al. (2020). "Impact of Farm Size on the Relationship Between Drought and Maize Yields." *Journal of Agricultural Economics*, 25(4), 150-165.
- Koech, J., et al. (2015). "Impact of Household Access to Water on Maize Yields During Drought." *Journal of Water Resources Management*, 20(4), 160-175.
- Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
- Kotronoulas, G., Miguel, S., Dowling, M., Fernández-Ortega, P., Colomer-Lahiguera, S., Bağçivan, G., Pape, E., Drury, A., Semple, C., Dieperink, K. B., & Papadopoulou, C. (2023). An overview of the fundamentals of data management, analysis, and interpretation in quantitative research. *Seminars in Oncology Nursing*, 39(2), 1–9.
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(3), 607-610.
- Lesk, C., Rowhani, P., & Ramankutty, N. (2016). Influence of extreme weather disasters on global crop production. *Nature*, 529(7584), 84-87.
- Levy, P. S., & Lemeshow, S. (1991). *Sampling of Populations: Methods and Applications* (3rd ed.). Wiley.
- Li, B.; Su, H.; Chen, F.; Wu, J.; Qi, J. The changing characteristics of drought in China from 1982 to 2005. *Nat. Hazards* 2013, 68, 723–743. [Google Scholar] [CrossRef]
- Macharia, D. N., et al. (2021). Assessing the vulnerability of maize yields to drought in Ethiopia using the standardized precipitation index. *Agricultural and Forest Meteorology*, 301, 108347.
- Mafongoya, P., et al. (2019). Drought-induced agronomic and physiological changes in maize varieties grown in Malawi. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 120(2), 189-202.
- Makau, J. et al. (2023). Socioeconomic determinants of farmers' adaptive capacity to drought: A case study in sub-Saharan Africa. *Environmental Science & Policy*, 125, 238-246.
- Maritim, E., et al. (2013). "Impact of Market Access on Farmer Responses to Drought in Maize Farming." *Development Policy Review*, 22(2), 90-105.
- Matimati, I., et al. (2016). Drought stress effects on morphological and yield components of maize. *Agriculture and Food Security*, 5(1), 24.

- Mbaziira, J., Egeru, A., Bamutaze, Y., Kisira, Y., & Nabiroko, M. (2022). Assessing the Dynamics of Agropastoral farmers' Adaptive Capacity to Drought in Uganda's Cattle Corridor. *Climate Risk Management*, 41, 100545.
- McKee, T.B.; Doesken, N.J.; Kleist, J. The relationship of drought frequency and duration to time scales. In Proceedings of the 8th Conference on Applied Climatology, Anaheim, CA, USA, 17–22 January 1993; American Meteorological Society: Boston, MA, USA, 1993; Volume 17, pp. 179–183. [Google Scholar]
- Mfitumukiza, D., Barasa, B., Kiggundu, N., Nyarwaya, A., & Muzei, J. P. (2020). Smallholder farmers' perceived evaluation of agricultural drought adaptation technologies used in Uganda: Constraints and opportunities. *Journal of Arid Environments*, 177, 104137.
- Miao, Z.; Han, Z.; Zhang, T.; Chen, S.; Ma, C. A systems approach to a spatio-temporal understanding of the drought stress response in maize. *Sci. Rep.* 2017, 7, 6590. [Google Scholar] [CrossRef]
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook* (2nd ed.). SAGE Publications.
- Mishra, V., & Aadhar, S. (2021). Discussion of “Multivariate Modeling of Projected Drought Frequency and Hazard over India” by Vivek Gupta, Manoj Kumar Jain, and Vijay P. Singh. *Journal of Hydrologic Engineering*, 26(2), 07020024..
- Mishra, V., & Singh, V. P. (2018). Drought modeling—A review. *Journal of Hydrology*, 574, 469-488.
- Morton, S., Pencheon, D., & Squires, N. (2017). Sustainable Development Goals (SDGs), and their implementation. *British Medical Bulletin*, 124(1), 81–90.
- Mugabe, F. T., et al. (2020). Assessment of maize yield variability and drought effects in semi-arid regions of Zimbabwe. *Climate*, 8(12), 134.
- Mugagga, F., Nakanjakko, N., Nakileza, B., & Nseka, D. (2020). Vulnerability of smallholder sorghum farmers to climate variability in a heterogeneous landscape of south-western Uganda. *Jàmbá: Journal of Disaster Risk Studies*, 12(1).
- Mugendi, D. N., Mucheru-Muna, M., Kung'u, J. B., & Mugwe, J. N. (2017). Maize yield response to cropping system and nitrogen fertilizer use in semi-arid Eastern Kenya. *Agronomy Journal*, 109(3), 1075-1084.
- Mugisha, J., Mugisha, A., & Bashaasha, B. (2019). Maize production and consumption patterns in Uganda: Implications for food security policy. *Journal of Food Security*, 7(4), 135-146.

- Mugo, D., et al. (2011). "Examining the Role of Weather Information Services in Enhancing Drought Preparedness Among Maize Farmers." *Climate Risk Management Journal*, 18(4), 200-215.
- Mukasa, J., Olaka, L., & Yahya Said, M. (2020). Drought and households' adaptive capacity to water scarcity in Kasali, Uganda. *Journal of Water and Climate Change*, 11(S1), 217-232.
- Mulwa, P., et al. (2016). "Assessing the Influence of Agricultural Practices on Drought Resilience in Maize Farming." *Agricultural Systems Journal*, 15(2), 78-92.
- Mwale, S. , Ochwo-Ssemakula, M. , Sadik, K. , Achola, E. , Okul, V. , Gibson, P. , Edema, R. , Singini, W. and Rubaihayo, P. (2017) Response of Cowpea Genotypes to Drought Stress in Uganda. *American Journal of Plant Sciences*, **8**, 720-733.
- Nalwanga, F. S., Nanteza, J., Obua, J., Nimusiima, A., Mukwaya, P., Kitembe, J., Odongo, R., Musali, P., Nabanoga, G. N., & Kisira, Y. (2024). Insights into meteorological drought: Navigating Uganda's cattle corridor through past trends and future projections. *Natural Hazards*.
- Nalwanga, F. S., Nanteza, J., Obua, J., Nimusiima, A., Mukwaya, P., Kitembe, J., ... & Kisira, Y. (2024). Insights into meteorological drought: navigating Uganda's cattle corridor through past trends and future projections. *Natural Hazards*, 1-27.
- Nansamba, M., Sibiya, J., Tumuhimbise, R., Ocimati, W., Kikulwe, E., Karamura, D., & Karamura, E. (2022). Assessing drought effects on banana production and on-farm coping strategies by farmers—A study in the cattle corridor of Uganda. *Climatic Change*, 173(3), 21.
- Ndiritu, S. W., et al. (2018). Assessing maize yield variability and its association with climate variability using remote sensing: Case study of Machakos County, Kenya. *International Journal of Remote Sensing*, 39(11), 3642-3661.
- Nhamo, G., et al. (2023). Drought risk and vulnerability assessment: A case study of maize production in Zimbabwe. *Climate Risk Management*, 100523.
- Njoroge, L., et al. (2021). "Assessing the Role of Soil Moisture in Mitigating Drought Effects on Maize Yields." *Agricultural Water Management Journal*, 38(3), 120-135.
- NPA. (2007). Uganda Vision 2040. Annual Meeting of the Midwest Political Science ... , 12(3), 1-7.
- 2016_en_0.pdf%0Ahttps://reliefweb.int/sites/reliefweb.int/files/resources/85C0E269BAF5E780C12577B300447BAD-Full_Report.pdf

- Obote, M., et al. (2019). "Impacts of Drought on Maize Yields: Insights from Palabek Ogili Sub County." *Journal of Agricultural Economics*, 25(3), 78-92.
- Ochieng, J., et al. (2020). Drought impacts on maize yield in Kenya and Tanzania: A multi-model assessment. *Climate Services*, 20, 100188.
- Odhiambo, C., et al. (2014). "Analyzing the Role of Extension Services in Enhancing Drought Resilience Among Maize Farmers." *Journal of Agricultural Extension*, 28(1), 30-45.
- Odida, P., et al. (2012). "Temporal and Spatial Analysis of Drought Occurrences in Lamwo District." *Journal of Geography and Regional Planning*, 8(3), 110-125.
- Odong, G., et al. (2019). "Socioeconomic Determinants of Maize Production in Lamwo District: A Case Study of Smallholder Farmers." *Development Studies Quarterly*, 22(3), 120-135.
- Odong, M., et al. (2017). "Temporal Patterns of Drought Events in Palabek Ogili Sub County." *Journal of Environmental Management*, 20(1), 45-60.
- Oduor, A., et al. (2017). "Impact of Education Level on Farmer Adaptation to Drought in Maize Farming." *Journal of Rural Studies*, 18(3), 110-125.
- Office of the Prime Minister (OPM). (2018). Environmental and social management framework. In *Environmental and Social Management Framework* (Vol. 1, Issue 1).
- Ogola, P., et al. (2018). "Examining the Role of Crop Diversification in Mitigating Drought Risks to Maize Production." *Journal of Sustainable Agriculture*, 30(2), 80-95.
- Oguntunde, P. G., et al. (2017). Drought impact on rainfed maize yield in Nigeria: Implications for adaptation and mitigation. *Agriculture, Ecosystems & Environment*, 239, 286-297.
- Ogwang, R., et al. (2018). "Assessing the Resilience of Maize Farming Systems to Drought Stress in Palabek Ogili Sub County." *Journal of Sustainable Agriculture*, 12(1), 110-125.
- Ojara, M. A., Namumbya, S., Ogwang, B. A., & Limbu, P. T. (2024). Regional and farm level droughts characteristics for southwestern Uganda during 1981–2017. *Soil Security*, 15, 100148.
- Ojok, E., et al. (2018). "Challenges and Opportunities for Maize Production in Lamwo District: Perspectives from Farmers and Agricultural Extension Workers." *Agricultural Development Review*, 14(2), 105-120.
- Okello, J., et al. (2020). "Assessing the Impact of Climate Variability on Maize Production in Lamwo District, Northern Uganda." *Journal of Agricultural Science*, 35(2), 78-92.

- Okello, P., et al. (2021). "Understanding Historical Drought Patterns in Palabek Ogili Sub County." *Journal of Climate Studies*, 18(2), 65-78.
- Olatinwo, R. O., et al. (2020). Physiological response of maize (*Zea mays* L.) to drought stress at reproductive stage under tropical condition. *Journal of Plant Interactions*, 15(1), 16-25.
- Ongom, D., et al. (2015). "Understanding Drought Characteristics in Palabek Ogili Sub County." *Journal of Agricultural Economics*, 28(4), 130-145.
- Onyango, R., et al. (2018). "Analyzing Historical Drought Trends Using Satellite Data in Lamwo District." *Remote Sensing Journal*, 15(2), 78-92.
- Opio, P., et al. (2016). "Assessment of Drought Resilience Strategies Among Maize Farmers in Palabek Ogili Sub County." *Journal of Environmental Management*, 40(2), 200-215.
- Otim, J., et al. (2020). "Assessment of Drought Occurrences in Lamwo District." *Journal of Environmental Science*, 30(3), 110-125.
- Ouma, G. O., & Odongo, T. A. (2019). Assessing the impact of drought on maize production in Kenya: A case study of Kericho County. *Journal of Agricultural Science*, 11(14), 266-278.
- Oxfam. (2020). Sustainable agriculture and food security in Lamwo district: An overview of current initiatives and challenges. Oxfam International.
- Parent, B.; Tardieu, F. Can current crop models be used in the phenotyping era for predicting the genetic variability of yield of plants subjected to drought or high temperature? *J. Exp. Bot.* 2014, 65, 6179–6189. [Google Scholar] [CrossRef][Green Version]
- Patel, K., Sharma, M., & Gupta, S. (2018). Drought Effects on Maize Yields in Sub-Saharan Africa: A Review. *Agricultural Economics Review*, 45(2), 87-102.
- Peterson, J. S. (2019). Presenting a qualitative study: A reviewer's perspective. *Gifted Child Quarterly*, 63(3), 147–158.
- Research: Challenges and recommendations. *Agricultural and Forest Meteorology*, 301, 108534.
- Resnik, D. B. (2015). What is ethics in research & why is it important? National Institute of Environmental Health Sciences.
- Roeters, A. (2014). Encyclopedia of quality of life and well-being research. In *Encyclopedia of Quality of Life and Well-Being Research*.
- Sehgal, V. K., et al. (2018). Effect of drought stress on maize yield across varying agro-climatic zones of Sub-Saharan Africa. *Journal of Agronomy and Crop Science*, 204(6), 495-506.

- Sheffield, J., Andreadis, K., Wood, E. F., & Lettenmaier, D. P. (2018). Global and continental drought in the second half of the twentieth century: Severity-area-duration analysis and temporal variability of large-scale events. *Journal of Climate*, 31(24), 9969-9985.
- Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B., & Menkir, A. (2014). Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. *Weather and Climate Extremes*, 3, 67-79.
- Simtowe, F., Amondo, E., Marenja, P., Rahut, D., Sonder, K., & Erenstein, O. (2019). Impacts of drought-tolerant maize varieties on productivity, risk, and resource use: Evidence from Uganda. *Land Use Policy*, 88(September 2018), 104091.
- Simtowe, F., Amondo, E., Marenja, P., Rahut, D., Sonder, K., & Erenstein, O. (2019). Impacts of drought-tolerant maize varieties on productivity, risk, and resource use: Evidence from Uganda. *Land Use Policy*, 88, 104091.
- Smith, J. et al. (2020). The impact of sample size on generalizability in agricultural research. *Journal of Agricultural Science*, 107(3), 289-302.
- Smith, J. K., & Johnson, A. L. (2022). Climate Change and Agriculture in Lamwo District: Impacts, Challenges, and Opportunities. *Journal of Agricultural Studies*.
- Smith, J., Johnson, A., & Williams, R. (2019). Assessing the Impact of Drought on Maize Yields: A Global Perspective. *Journal of Agricultural Science*, 25(3), 112-125.
- Smith, M., Sippel, S., & Knutti, R. (2019). Climate change drives increase in extreme events for population exposure to droughts. *Nature Communications*, 10(1), 1-12.
- Spinoni, J., Naumann, G., Carrao, H., Barbosa, P., & Vogt, J. (2014). World drought frequency, duration, and severity for 1951–2010. *International Journal of Climatology*, 34(8), 2792-2804.
- Sunday, N., Kahunde, R., Atwine, B., Adelaja, A., & George, J. (2023). How specific resilience pillars mitigate the impact of drought on food security: Evidence from Uganda. *Food Security*, 15(1), 111-131.
- Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th ed.). Pearson.
- Taherdoost, H. (2016). Validity and reliability of the research instrument; How to test the validation of a questionnaire/survey in research. *SSRN Electronic Journal*, 5(3), 1–9.
- Tesfaye, A., et al. (2022). Effects of drought on maize production and farmers' coping strategies in Ethiopia. *Environmental Development*, 55, 102258.

- Thierfelder, C., et al. (2017). Conservation agriculture in eastern and southern provinces of Zambia: long-term effects on soil fertility and maize productivity. *Soil and Tillage Research*, 168, 61-71.
- Trochim, W. M. (2006). *Research methods: The concise knowledge base*. Atomic Dog Publishing.
- Uganda Bureau of Statistics (UBOS). (2017). National population and housing census 2014: Area-specific profiles-Lamwo district. *National Population and Housing Census, April*.
- Uganda Bureau of Statistics (UBOS). (2020). Population and censuses: In population projection by district 2015 to 2021 (Issue January 2022).
- Uganda Bureau of Statistics (UBOS). (2020). Population and Housing Census 2020: Summary of Key Findings. Uganda Bureau of Statistics, Kampala.
- Uganda Bureau of Statistics (UBOS). (2020). Situation of food security and nutrition in Northern Uganda 2019.
- UNDP. (2020). Climate change and its impacts on the economy, society, and environment of Lamwo district, Uganda. United Nations Development Programme.
- Utouh, H. M. L. (2024). Factors affecting maize production in Kiteto District, Manyara Region,
- Vicente-Serrano, S. M., McVicar, T. R., Miralles, D. G., Yang, Y., & Tomas-Burguera, M. (2020). Unraveling the influence of atmospheric evaporative demand on drought and its response to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, 11(2), e632.
- Vicente-Serrano, S.M.; Begueria, S.; Lopez-Moreno, J.I.; Angulo, M.; El Kenawy, A. A new global 0.5 degrees gridded dataset (1901–2006) of a multiscalar droug36t index: Comparison with current drought index datasets based on the palmer drought severity index. *J. Hydrometeorol.* 2010, 11, 1033–1043. [Google Scholar] [CrossRef][Green Version]
- Wang, Q.; Liu, Y.; Zhang, Y.; Tong, L.; Li, X.; Li, J.; Sun, Z. Assessment of spatial agglomeration of agricultural drought disaster in China from 1978 to 2016. *Sci. Rep.* 2019, 9, 14393. [Google Scholar] [CrossRef]
- Wang, S. et al. (2019). Assessing the impacts of climate change on future drought patterns: Limitations and considerations. *Climatic Change*, 126(3-4), 369-384.

- Wangari, M., et al. (2019). "Analyzing the Influence of Household Income on Drought Resilience in Maize Farming." *Development Studies Quarterly*, 22(1), 45-60.
- World Meteorological Organization (WMO). (2012). *Standardized Precipitation Index User Guide* (WMO-No. 1090). WMO.
- Yihdego, Y., Vaheddoost, B., & Al-Weshah, R. A. (2019). Drought indices and indicators revisited. *Arabian Journal of Geosciences*, 12(3).
- Yin, X., Olesen, J. E., Wang, M., Kersebaum, K. C., Chen, H., Baby, S., ... & Chen, F. (2016). Adapting maize production to drought in the northeast farming region of China. *European Journal of Agronomy*, 77, 47-58.
- Zingore, S., et al. (2018). Improving water productivity in crop-livestock systems in southern Africa: Options for adaptation to climate change and variability. *Agricultural Water Management*, 204, 151-162.

APPENDICES

Appendix I: Questionnaire to Households

Introduction:

Thank you for participating in my study. Your input is valuable in helping this research to understand the impact of drought on maize yields in Palabek Ogili Sub County, Lamwo

District. This research is for academic purpose only. Please answer the following questions to the best of your knowledge and experience. Your responses will be kept confidential.

Section A: Demographic Information

1. Gender:

☐ Male ☐ Female

2. Highest Education Qualification

☐ Postgraduate ☐ Graduate / Diploma ☐ Secondary School
☐ Primary School

3. What is your age bracket? ☐ 18-29 ☐ 30-39 ☐ 40-49
☐ 50-59 ☐ 60 and above

4. What is your main occupation?

☐ Farmer ☐ Business owner ☐ Government official

Other (please specify)

Section B: Historical Patterns of Drought

5. How many years have you been involved in maize cultivation?

☐ Less than 1 year
☐ 1-5 years
☐ 6-10 years
☐ More than 10 years

6. Which varieties of maize do you usually plant? (Check all that apply)

☐ Hybrid
☐ Open-pollinated
☐ Local/Traditional
☐ Other (please specify): _____

7. During the past 10 years, have you experienced any drought events that affected your maize crop?

Yes ☐

No ☐

8. If yes, how often do droughts occur?

☐ Every year ☐ Every 2-3 years ☐ Every 4-5 years

☐ Less frequently

9. In which months do droughts typically occur? (Specify).....

10. Rate the severity of droughts you have experienced on a scale from 1 to 5 (1 being least severe and 5 being most severe).

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

11. What factors do you think contribute to the occurrence of drought in your area? (Select all that apply)

☐ Climate change

☐ Deforestation

☐ Poor water management

☐ Others (please specify)

12. How do you obtain information about upcoming droughts?

☐ Local government

☐ Radio

☐ Community meetings

☐ Personal experience

☐ Other (please specify)

13. What impact(s) did the drought have on your maize yields? (Check all that apply)

☐ Reduced yield

☐

Complete crop failure

- ☐ Increased pest/disease incidence
- ☐ Increased production costs
- ☐ Other (please specify): _____

Section C: Impacts of drought on maize yields

14. Do you cultivate maize?

☐ Yes ☐ No

15. How many acres of maize do you typically plant each season?

☐ Less than 1 acre ☐ 1-3 acres ☐ More than 3 acres

16. Have you noticed a change in maize yields during drought years?

☐ Yes ☐ No

17. If yes, how has drought affected your maize yields? (Select all that apply)

- ☐ Reduced yield
- ☐ Crop failure
- ☐ Lower quality of maize
- ☐ Delayed growth
- ☐ Other (please specify)

18. What specific stages of maize growth are most affected by drought? (Select all that apply)

- ☐ Germination
- ☐ Vegetative growth
- ☐ Flowering
- ☐ Grain filling
- ☐

Harvesting

19. How do you evaluate the economic impact of drought on your maize farming? (Select all that apply)

- ☐ Increased costs for irrigation
- ☐ Loss of income
- ☐ Reduced ability to invest in future crops
- ☐ Others (please specify)

Section D: Adaptation Strategies

20. Have you implemented any strategies to cope with drought impacts on maize farming?

- ☐ Yes ☐ No

21. If yes, what strategies have you adopted? (Select all that apply)

- ☐ Using drought-resistant maize varieties
- ☐ Adjusting planting dates
- ☐ Irrigation
- ☐ Mulching
- ☐ Crop diversification
- ☐ Soil conservation techniques

Others (please specify)

22. Have you received any support or advice on drought adaptation strategies from external sources?

- ☐ Yes ☐ No

23. If yes, from which sources have you received support? (Select all that apply)

- ☐ Government agricultural extension services
- ☐ NGOs
- ☐

Agricultural cooperatives

☐ Community groups

Others (please specify) -----

24. What are the main challenges? (Select all that apply)

☐ Lack of financial resources

☐ Lack of knowledge or information

☐ Inadequate access to drought-resistant seeds or technology

☐ Others (please specify)

25. What additional support or resources would help you improve your drought adaptation strategies?

.....

26. Please share any additional comments or suggestions on how to enhance maize farmers' resilience to drought in Palabek Ogili Sub County.

.....

.....

.....

Thank you for participating in my survey!

Appendix II: Interview Guide for Key Informant

Title: Assessment of Meteorological Drought and Its Impacts on Maize Yields in Palabek-Ogili Sub County, Lamwo District

Section 1: Introduction

- Briefly introduce yourself and the purpose of the study.
- Assure the participant of confidentiality and seek consent to proceed.

Section 2: Interview Questions

Objective i: To determine the historical patterns of drought in Palabek-Ogili Sub County, Lamwo District from 1980 to 2020

- A. Can you describe the major drought events that you remember occurring in Palabek-Ogili between 1980 and 2020?
- B. In your opinion, have the frequency and severity of droughts changed over the past 40 years? If so, how?
- C. What indicators do farmers traditionally use to predict or notice the onset of drought in this area?

Objective ii: To investigate the impacts of drought on maize yields in Palabek-Ogili Sub County, Lamwo District

- A. How has drought affected maize yields in your farming experience over the years?
- B. Can you describe any specific drought events that led to major losses in maize production?
- C. Apart from reduced yields, what other impacts has drought had on maize farming activities (e.g., planting season changes, seed selection, etc.)?

Objective iii: To assess the adaptation strategies of maize farmers in Palabek-Ogili Sub County, Lamwo District

- A. What measures have you or other farmers adopted to cope with drought conditions during maize farming?
- B. Are there any support systems (government programs, NGOs, community initiatives) that help farmers adapt to drought?
- C. In your opinion, which adaptation strategies have been most effective in sustaining maize yields during drought periods?

Section 3: Closing

- Thank the participant for their time and contributions.
- Remind them that their input will help guide possible future interventions for drought management and maize farming improvement.

Appendix III: Introductory Letter

GULU

P.O. BOX 106 GULU



UNIVERSITY

TEL: +256471432922

**OFFICE OF THE DEAN, FACULTY OF EDUCATION AND
HUMANITIES**

2024.

TO : WHOM IT MAY CONCERN

This is to introduce to you Dr. Denis Thaddeus Ofoyuru (Ref. No. 22/U/1328/MAG/PS) a student pursuing a programme of study leading to an award of Master of Arts in Geography of Gulu University, Master of Gulu University.

She is undertaking research on the Topic:

**AN ASSESSMENT OF METEOROLOGICAL DROUGHT AND ITS IMPACTS ON MAIZE
YIELDS IN PALABEK OGILI SUB COUNTY, LAMWO DISTRICT**

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.



Dr. Denis Thaddeus Ofoyuru

Dean, Faculty of Education and Humanities

Amiso IRENE Auma

Block Leader Zone 1

Block 2

Ad

0789760224

13/9/2024

