FARMERS' PERCEPTION OF THE EFFECTS OF CLIMATE VARIABILITY ON RICE PRODUCTION AND ADAPTATION STRATEGIES

THE STUDY OF LIMOTO WETLANDS,

KIBUKU DISTRICT UGANDA

BY

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DECLARATION

I, **Kaugule Joseph**, hereby declare that this dissertation, submitted to the Faculty of Natural Resources and Environmental Science, is my original work. To the best of my knowledge, it has not been submitted to any other institution for the award of a degree or any other purpose. All sources used have been properly acknowledged.

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APPROVAL

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DEDICATION

I dedicate this dissertation to my family, especially my children (Kaugule Jethro Elvis, Nangobi Annah Patience, Kirabo Josephine, and Kaugule Jennifer), my mother, my father, my brothers and my sisters, whose unwavering support and encouragement have been my greatest source of strength. To my beloved wives, whose patience and understanding have been invaluable throughout this journey of education.

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Abstract

The main objective of the study was to assess the farmers' perception of the effects of climate variability on rice production in Limoto wetlands in Kibuku district. The research was cross-sectional in nature where both quantitative and qualitative approaches to produce data on historical trends and challenges of climate variability, farmers' perceptions of the impacts of climate variability on rice production and factors influencing adaptation strategies that would allow rice farmers to shape sustainability and resilience to their livelihoods. Both purposive sampling and Simple random sampling were employed to select respondents from both rice farmers and key informants in the two sub-counties of Buseta and Kituti within Kibuku district comprised a population of 900 active farmers and were only 268 were sampled during the study, 160 were from Buseta Sub-County, while 108 were from Kituti Sub-County. Data on monthly temperature and rainfall for the period 1995–2024 were obtained from the department of Meteorological services, under the Ministry of Water and Environment. This period matches a minimum of 30 years. Rice farmers' perceived impacts of climate variability on rice production relied on cross-sectional data from 268 rice farmers interviewed using a combination of semi structured questionnaires. The medians within each boxplot indicated a slight temperature upward shift over time, particularly from the 1990s to the 2010s. Contrastingly, the annual rainfall does not show any monotonic trend, despite substantial inter-annual variability. Statistical tests revealed that inter-annual variability in rainfall, with extreme anomalies observed in 2000 and 2016 had SPI values below -2, signifying severe drought years. Conversely, 1996, 2007, and 2019 had SPI values above +1.5 significantly wetter conditions. These findings were consistent with findings from responses obtained from FGDs and KIIs. The results from the analysis of minimum temperature were consistent with those of maximum temperature, where the decadal increase in maximum temperature was significant between the 1990s and 2010s. The medians within each boxplot indicate a slight upward shift over time, particularly from the 1990s to the 2010s. However, the 2020s appear to show a stabilization or slight reduction in median maximum temperatures. Contrastingly, the annual rainfall does not show any monotonic trend, despite substantial inter-annual variability. The demographic and socio- characteristics revealed education, social, and technological involvement to enhance adaptation. The study concluded that significant climatic shifts have occurred in both rainfall and temperature patterns, including the frequency of dry spells and elevated mean temperatures. It was also concluded by the results there is evident decline in rice kilograms over the last three decades.

It was recommended that enhancement of adaptation through improved means of support, and make sure food is enough in people's homes amidst an increasingly uncertain climatic future, scaling up to equip farmers with knowledge on adaptation practices, sustainable land use, and policies that encourage livelihood options in income-generating activities

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Globally changes in Climate has substantially affected agricultural food systems in terms of soil exhaustion for instance, it is documented that Ten percent of the arable land for crop cultivation is predicted to be climatically unsuitable for farming in the next century in accordance with IPCC's 6th Assessment Report on Climate Change. It is projected that increased climate extremes will routinely and potentially lead to losses of agricultural crops hence reducing food-production many countries (IPCC. Climate Change 2021)

Climate change events affect the world's most vulnerable countries and over 70% of the world's low-income countries depend on farming and directly on the environment for their survival. The global number of people is predicted to be approximately 10 billion by 2050. Therefore as a result of increased climate changes on population, growth and development, and lifestyle, the agricultural production of primary crops including rice was 9.2 billion tons globally in 2018, which was around 50% more than in 2000 (IPCC. Climate Change 2021).

It is documented that globally, the predicted impacts of climate changes on crop farming and its yields occur differently according to their locations. Different Regions show different climate shifts in accordance with their socioeconomic situations and such regions exhibit climate changes differently in terms of in temperature patterns, precipitation patterns and other weather events. The climatic changes pose severe ricks to humans, agricultural systems among others through exposure vulnerabilities as a result of poor or no adaptation capabilities (Rosenzweig, C. et al (2014).

Climate change indicates that at the global levels, rainfall patterns seriously impact the intercontinental variability in crop yields and agriculture generally and this increases the vulnerability especially to the crop producers, consumers and government in terms increased expenditures. All agricultural farming systems worldwide are vulnerable to climate changes for instance, global climate patterns in crop yield losses shows the behaviors of crops to temperatures changes coupled with the rising extreme heat depressing the crop yields and reductions in cold days increase the crop yields (Schlenker, W. et al (2009).

In sub Saharan Africa, climate trend patterns are common around equatorial regions of the world with high rainfall, including central Africa, and some parts of Southeast Asia and South America. In Such regions, the importance of appropriate temperatures are determined by the increase in rainfall levels which is determined by increasing water cycle. It should be noted that though increasing temperatures would eventually affect the crop yields in such countries, the importance of increased precipitation in such regions partly surpasses effects (Barros, V. R. et al. (2014)

Adaptation to climate change events especially to the increasing temperatures which lead to reasonable impacts to extreme weather events such as extreme heat is always in line with crop farmers adopting adaptation strategies to temperature extremes that are expected in future. The relationships between temperature flexibility and regular crop yields have been recorded and is meant to show physical relationships cross the regions in terms of growths (Hertel, T. W. et al (2014).

In Uganda, Rice farming plays crucial role for Uganda’s agricultural landscape, enhancing significantly to food households and as means of support (Baffour-Ata et al., 2021). It is a staple food for many households and a basis of earnings for many small-scale rice growers across the country (Akhtar et al., 2008). Nationally, rice is a key agricultural product, and its production has been expanding over the years. Rice cultivation in Uganda has been gradually evolving since 1904 and farmers started growing rice seriously in the country by the farmers in early and mid-1990s. During that time, rice farmers were basically growing rice at the subsistence levels for mostly home consumptions in accordance Uganda Bureau of Statistics (UBOS, 2004).

According to the Uganda Bureau of Statistics, rice farming supports the livelihoods of an estimated 300,000 Ugandan households, providing both food and income. The contribution of rice to Uganda's agricultural Growth Domestic Product is substantial (UBOS 2010).

Rice contributes approximately 12.1% to the gross domestic product in Uganda through increase export earning incomes, food security and nutrition security, and support to other livelihood enterprises in rural population. Therefore the Ugandan Government prioritizes rice to be a main agricultural crop with ability to contribute to steer the country’s economic growth and development (GoU, 2010). In order to effectively support rice production in the country, the government introduced the National Rice Development Strategies (NRDS) as a measure for rice promotion (GoU, 2009). This has led to effective reflection of the importance rice in the agricultural sector and its role in enhancing household incomes and food security.

However, the sustainability of rice farming in Uganda is increasingly threatened with variabilty in temperature, precipitation patterns, and extreme weather events, all of which are manifestations of climate variability and change (Tollens et al., 2013). For instance, changes in rainfall patterns can lead to either drought or flooding, both of which adversely affect rice yields (Akhtar & Nazir, 2013). Additionally, increasing temperatures can exacerbate the stress on rice crops, reducing their growth and production (Akman, 2009).

The shifts in Uganda's climate patterns have gradually increased since 1860s for instance, the temperature in Uganda has gradually increased since 1960s is approximately 1.3'c (minimum temperature increasing by 0.5-1.2'c and maximum temperature increasing by 0.6-0.9'c and the Rate of increase per decade since 1960s is approximately 0.28'c. The mean annual temperature is predicted to rise by between 1.0 and 3.1°C by the 2060s, and between 1.4 and 4.9°C by the 2090s. This projection puts Uganda and its population more vulnerable. This is as a result of increasing encroachment on the fragile ecosystems such as wetlands and little or no immediate plans for the adaptation measures amidst the escalating climate changes in the country. The shifts in climate patterns leads to erratic weather events including floods, this pushes further the population more vulnerable climatic conditions. The erratic events are expected to increase leading to loss of people's property and sometimes deaths Spencer R. et al (2008).

Despite the growing recognition towards the effects of climatic changes on farming systems, limited empirical research has focused on understanding its specific implications for rice farming in specific ecosystems such as wetlands. Existing studies have predominantly addressed broader agricultural challenges or focused on other regions, leaving a critical gap in understanding the unique vulnerabilities and adaptation needs of rice farmers in specific locales (Stuecker et al., 2018).

In Uganda, wetland areas are heavily utilized for rice-growing and other agriculture related activities and this contributes about 21% of national gross domestic product and employs over 70% out the people in the country (UBOS, 2014). Uganda is alienated into seven agro ecological areas described in relationship to economic and social assimilations, ecosystem situations including the soil types, terrain, precipitation and crop agricultural systems and adaptation practices which are almost similar (Mwebaze, 2002). The south eastern zone is among the zones south-Eastern agro-ecological Zone (SEAEZ) which includes Bukedi where is Kibuku is found and Limoto wetlands in particular, Busoga and Mt. Elgon sub zones in Eastern Uganda (UBOS, 2014).

The Limoto Wetlands in Kibuku district, in particular, are prominent rice-growing areas (Ochieng et al., 2016). This wetland-based rice farming supports the livelihoods of thousands of small-scale farmers who rely on the seasonal flooding and unique soil conditions provided by the wetlands (Baffour-Ata et al., 2021).

Uganda’s wetlands been the hub for the influx of farmers and household over time for race growing in order to secure food security and increase on people’s incomes and as a result of climate variability and change, wetlands rice cultivation as a resilient adaptation strategy mostly in places with upland soil infertility and relatively poor soils and erratic rainfall. Wetlands always have water either seasonally or permanently and this is helpful especially long dry spell and seasons. Uganda’s Wetlands have fertile soils good for food production to both directly in the dry season and indirectly by income generation through crop sales, and the sale of items harvested from wetlands and this guarantees safety for the surrounding population (Turyahabwe N et al (2013).

Changes in climate patterns locally can also change farmer’s ways with consequences for the agricultural environment they are operating hence, impacting on their livelihood (UNFCC, 2007). Climate change and variability is reducing on the crop yields which reduces incomes to the farmers in developing countries who entirely depend on rain fed for agriculture production (Apata, 2010).

Crop agricultural systems depend entirely on climate variability and related aspects and this is an important part of the socioeconomic development in less developed countries. The changes in Climate are predicted indicate a substantial expansion in precipitation patterns and rise in temperature to extreme weather events currently (Cline, 2008). For instance, the rise in temperatures is expected to lead to severe floods leading to crop yields reduction and loss (Mendelsohn, 2007).

Like other areas and farming systems, rice farming in wetlands is susceptible to changes in climate dynamics. The susceptibility can be exacerbated by the socio-economic context, including increasing of poverty, lack of financial resources, reliance on rain-fed agriculture (FAO, 2017; UBOS, 2020). Small-scale rice farmers always suffer economic means including technical expertise for supporting adaptive measures, further amplifying their susceptibility to climate-related risks (FAO, 2017). Additionally, the socio-cultural dynamics within a given community, including gender disparities in land ownership and decision-making, can influence for acceptance of adaptation practices that exacerbate vulnerabilities (Kabeer, 2005; UNDP, 2019).

The increased urbanization and land-use changes in areas near wetlands further complicate the challenges faced by rice farmers, as they change the hydrological patterns, increase pollution, and reduce the resilience of wetland ecosystems (KCCA, 2018; MAAIF, 2016). Encroachment on wetlands for infrastructure development and agricultural expansion positions severe risk to both ecological wetlands functions for the livelihoods of small rice farmers who depend on these wetlands for their sustenance (KCCA, 2018).

Basing on such climate variability issues, there is crucial requirements for holistic methods for incorporating climate adaptation through broader development objectives for supporting the sustainability of rice cultivation in wetlands. Such approaches should prioritize the participation of local stakeholders, including small-scale farmers, in decision-making processes and ensure that interventions are contextually appropriate and socially inclusive. By addressing the underlying drivers of vulnerability and fostering synergies between climate adaptation, sustainable land management, and socio-economic development, it is possible for supporting sustainability equitable farming methods for withstanding the effects of climatic variables for the future.

Understanding historical trends of climate variability how these relate to rice production is imperative for informing adaptation and mitigation strategies to safeguard rice production and means of support for rice farmers (Kijima, 2012). The research seeks to solve this gap through assessing of the relationship between trends in climate and rice production, examining the historical climatic trends in climate to elucidate the impact of climate variability on rice production and Identifying adaptation and managing means employed by individual holder rice growers in response to the changing extreme weather state

1.2 Statement of the Problem

Agricultural farming system in Uganda is highly susceptible to the effects of climate variability. Rice production, in particular, is under threat from shifting climatic patterns, including alterations in temperature regimes, erratic precipitation, and fragile occurrences of extreme weather events (Omondi et al., 2020; Nabikolo et al., 2019). In eastern part of the country, the Limoto Wetlands in Kibuku District serve as a critical area for rice cultivation, providing both sustenance and income for local farmers (Mugagga et al., 2019). Thirty years to date, there were general shifts in climate patterns which have significantly affected agricultural activities (Nsubuga et al., 2014). Unpredictable weather events disorganize planting and harvesting schedules, reduce crop yields, and increase the vulnerability of rice crops to pests and diseases (Kyazze & Kristjanson, 2011). These climatic changes pose a significant threat to alternative options of rice farmers depending heavily on rice cultivation, especially along wetland areas.

However, empirical research focusing on the specific implications of climate variability on rice farming in wetland areas remains scarce, highlighting a critical knowledge gap that hinders informed decision-making to improve the resilience of farmers. In response to the challenges posed by climate variability, farmers, especially in wetlands, have adopted various adaptation measures to sustain their rice production, including adjusting planting dates, using drought-resistant rice varieties, implementing water management practices, and most importantly, diversifying income sources (Kisakye et al., 2018). However, what informs these adaptation strategies, especially diversification of income sources, remains under-examined. A comprehensive assessment of the current adaptation actions carried out by rice producers is necessary to understand their adequacy and to develop recommendations for improving their resilience to climatic variables. The research aimed at understanding historical trends and develop effective approaches for preventing adverse effects for climate variability on rice production.

1.3 Objectives of the study

1.3.1 Main Objective

The main objective of this study was to assess the farmers' perception of the effects of climate variability on rice production and adaptation strategies in Limoto wetlands in Kibuku district.

1.3.2 Specific Objectives

1. To describe the trends and challenges of climate variability around Limoto wetlands (Kibuku District) for the period 1995-2024.
2. To assess the farmer's perceived impacts of climate variability on rice production and the factors that shape these perceptions in Limoto wetlands in Kibuku district.
3. To evaluate the factors influencing the effectiveness of adaptation to climate variability by the rice farmers in Limoto wetlands.

1.4 Research questions

i. What are the trends and challenges of climate variability (e.g., temperature, rainfall) around Limoto wetlands, Kibuku District, from 1995-2024

ii. How do rice farmers perceive the impacts of climate variability on rice production in Limoto wetlands and what factors shape these perceptions?

iii. What are the factors influencing the effectiveness of adaptation strategies to climate variability on rice production?

1.5 Significance of the study

The study generated information that would be applied for policy formulation and intervention strategies aimed at enhancing the resilience of rice production systems, both in Limoto wetlands and other areas with similar agricultural landscapes and facing the same challenges globally.

This research has the potential to lead to development changes in agricultural practices, resource allocation, and policy priorities to address the diverse relationship between climate variability and rice production.

1.6 Significance of the study

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1.7 Justification of the Study

Rice farming contributes vital parts to country’s growth and development in terms of food security to households, provision of incomes which can be used to services other basic need, contributes to Uganda’s growth domestic products in terms of export earnings which can be used to develop other infrastructure in the country. Sustainable Rice production is however threatened by increasing climate variability in terms of long dry spell and increased rainfall that leads to vulnerability of rice farmers leading to socio economic issues for example poverty, land tenure systems, limited aces to financial loans and this definitely limits the rice farmers to achieve adaptation strategies. Therefore, the information produced from the study would help Buseta and Kituti sub counties and Kibuku district local government to come up with strategies intended to sustain rice farming, Government would come up with informed policies for decision making for the resilience of rice production and guide further researchers in future.

1.8 Scope of the Study

1.8.1 Time scope

The duration of time taken whole conducting this research study took the whole of the second-year academic year hence the research process took fourteen months to complete the research process that is from June 2024 to October 2025 respectively

1.8.2 Content scope

The theme of the research study was the assessment of the farmers’ perception of the effects of climate variability on rice production and adaptation strategies in Limoto wetlands in Kibuku district. The research also involved sub themes such as description of the trends and challenges of climate variability around Limoto wetlands (Kibuku District) for the period 1995-2024, assessing the farmer’s perceived impacts of climate variability on rice production and the factors that shape these perceptions, and the evaluation of the factors influencing the effectiveness of adaptation to climate variability by the rice farmers in Limoto wetlands.

1.8.3 Geographical scope

Geographically the study was conducted in the Limoto Wetlands, Eastern Uganda. Limoto wetlands comprise a complex network of interconnected wetlands (Figure 2), geographically, Kibuku District is bordered by Pallisa District to the north, Budaka District to the east, Butaleja District to the south, and Namutumba District to the west. The district headquarters at Kibuku, are located approximately 53 kilometres (33 mi), by road, west of Mbale, the largest city in the sub-region. The coordinates of the district are: 01 02N, 33 50E. Kibuku District's vegetation is characterized by swamps, which cover a significant portion of the land, and woodlands. Kibuku district was selected because it contains more than 50% of the total area of the Limoto wetland complex. In addition, Kibuku district dominates rice growing in the wetland area compared to other districts that share the wetlands. Still, within the Kibuku district, the extent of rice farming varies in different sub-counties. The district comprises 17 sub-counties and five town councils, totaling 22 geo-political divisions. Of these divisions, more than 70% of the total production occurs in two sub-counties: Buseta and Kituti. Consequently, the study was narrowed to these two wetlands (Figure 2).

The Limoto wetland complex is characterized by unique ecological features, comprising vast areas of marshes, swamps, and seasonally flooded areas. The wetland complex and its surrounding areas are characterized by four seasons: the long and short wet seasons, typically occurring from March to May and September to November, respectively, and the long and short dry seasons, typically occurring between June and August and December and February, respectively (Basalirwa, 1995). These seasons correspond to the classification in Komutunga and Musiitwa (2001) for Uganda. The socio-economic value of the Limoto Wetlands is high, with agriculture being the primary economic activity (Turyahabwe et al, 2013). Small-scale rice farming is dominant, with farmers relying on rain-fed cultivation to grow various rice varieties. Traditional Fishing, livestock rearing, and pet trade comprise livelihood diversification options for the rice farmers. However, the area faces challenges related to poverty, limited access to basic services, and environmental degradation which could undermine the sustenance of rice farmers amidst climate change (Ellis, 2000b).

The two sub-counties in Kibuku district (that is, Buseta and Kituti) has about 900 active rice farmers within the Limoto Wetlands. This population was derived from information from various sources, including data provided by agricultural extension officers, agricultural cooperatives, farmer associations, and other agriculture-related organizations operating in the study area. Demographically, population of rice farmers in the study area reflects a diverse range of age groups, genders, and socio-economic backgrounds. While the majority of rice farmers are typically adults of working age, both men and women are actively engaged in rice farming, with women playing significant roles in various aspects of rice production, including land preparation, planting, and post-harvest processing.

1.8.3.1 The physical environment of Kibuku district

1.8.3.1.1 Soils in Kibuku district

Kibuku District has two dominant soil types: ferralitic and hydromorphic soils. The district's soils are generally fertile and productive, with well-drained sandy-clay loam and sandy-loam soils being common in some areas. Some areas are also characterized by black clays and dark grey clays, which can be productive with irrigation.

1.8.3.1.2 Wetlands in Kibuku district

Kibuku District has an extensive network of wetlands, particularly associated with the Mpologoma River, which are crucial for local ecosystems and livelihoods. These wetlands, including the shared Limoto wetland, have faced significant degradation from human activities like rice cultivation, prompting government and local efforts to restore them through demarcation, tree planting, and community engagement. These initiatives are supported by projects that provide alternative livelihoods and implement sustainable land management practices.

1.8.3.1.3 Average Temperature in Kibuku district

The hot season lasts for 2.3 months, from January 6 to March 15, with an average daily high temperature above 90°F. The hottest month of the year in Kibuku is February, with an average high of 92°F and low of 65°F. The cool season lasts for 5.5 months, from April 19 to October 2, with an average daily high temperature below 84°F. The coldest month of the year in Kibuku is August, with an average low of 62°F and high of 82°F.

1.8.3.1.4 Precipitation in Kibuku district

A wet day is one with at least 0.04 inches of liquid or liquid-equivalent precipitation. The chance of wet days in Kibuku varies very significantly throughout the year. The wetter season lasts 8.0 months, from March 20 to November 22, with a greater than 46% chance of a given day being a wet day. The month with the wet days in Kibuku is May, with an average of 21.6 days with at least 0.04 inches of precipitation. The drier season lasts 4.0 months, from November 22 to March 20. The month with the fewest wet days in Kibuku is January, with an average of 5.7 days with at least 0.04 inches of precipitation. Among wet days, we distinguish between those that experience rain alone, snow alone, or a mixture of the two. The month with the most days of rain alone in Kibuku is May, with an average of 21.6 days.

Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 75% on May 3.

1.8.3.1.5 Flora and fauna in Kibuku district

Kibuku district's flora and fauna are significantly impacted by high rates of charcoal burning and deforestation, which threaten local trees and biodiversity, although specific species lists are not readily available. The district's landscape is characterized by a mix of swamps and fragmented land, which supports some species but also limits agricultural expansion. Flora (Plants) Deforestation: Widespread tree felling for charcoal burning and timber is a major concern. Threatened species: The district faces the risk of many tree species becoming extinct due to this practice, including fruit trees like mangoes, jackfruits, and avocados. Mitigation efforts: The district forest department is encouraging replanting and has distributed tree seedlings, but a lack of funding and enforcement of the National Forest and Tree Planting Act are major hurdles.

1.8.3.1.6 Settlement patterns in Kibuku district

Kibuku district's settlement patterns are largely dictated by its challenging geography, with most land covered by swamps and limited arable land, leading to dispersed rural settlements focused on subsistence agriculture. The high population density on the available land and the presence of large, extended households, particularly in rural areas, are key characteristics. These patterns contribute to significant unemployment and development challenges.

Key settlement characteristics

1.9 Conceptual framework

The dependent variables for this study include Rice per Kilogram per area. These dependent variables are directly driven by independent variables including historical temperature trends, historical precipitation patterns, dry season and wet season. The effect of the independent variables and dependent variables are moderated by implementation of adaptation measures including, policies on sustainable wetland rice farming in the country, competent government technical staff to provide agricultural extension services to the rice farmers, lead institutions on rice farming make and supervise policy implementation appropriate to rice farming in the country, strategies on soil and water conservation and management, Farmer awareness and knowledge of climate variability and adaptation strategies , and social and community cooperative networks.

Figure 1: Conceptual Framework shows the relationship between these variables

Independent Variables

- Temperature trends
- precipitation patterns
- Dry season
- Wet season

Dependent Variable

- Rice Kilogram per area

Moderating factors

- Legal frameworks including laws and policies on sustainable wetland rice farming in the country
- Competent government technical staff to provide agricultural extension services to the rice farmers
- Lead institutions on rice farming make and supervise policy implementation appropriate to rice farming in the country.
- Strategies soil and water conservation management
- Farmer awareness and knowledge on climate adaptation strategies
- Social and community cooperative networks

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter presented scholarly information about many scholars on the study phenomenon. The study first dwells on the back ground information about trends of climate variability on rice production, followed by farmers perception of the impact of climate variability, then the adaptation strategies to climate variability literature is presented.

2.2 Theoretical framework

2.2.1 The Climate Change Adaptation Theory

This theory was rooted in the Intergovernmental Panel on Climate Change frameworks (IPCC, 2021), showing that shifts in climatic variables such as the observed increase in temperature and fluctuating precipitation drive changes in natural capital, including the significant decline in wetland areas. In the East African context, where rice cultivation relies heavily on wetland ecosystems coupled with climate variability vulnerabilities, this theory highlights the importance of assessing how these environmental and climate variability affects the land use dynamics and necessitate adaptation responses (Serdeczny et al., 2017).

2.2.2 The Theory of Planned Behavior (TPB)

Proposed by Ajzen (1991), suggests that attitudes toward climate impacts (that is, belief in temperature or rainfall effects on rice yields), subjective norms shaped by community practices, and perceived behavioral control influenced by resource access, for example, irrigation or land size, collectively determine acceptance of adaptation strategies. In the East African smallholder context, where farmers face diverse climatic challenges, the theory of Planned Behaviors can provide insight into why some farmers perceive climate variability as a barrier to rice production; yet, others see opportunities for change (Mase et al., 2017). By combining household surveys and statistical techniques such as logistic regression analyses, the Theory of Planned behaviors can explain how these perceptual factors drive the uptake of resilience-building practices, thereby linking farmer insights to tangible outcomes in terms of availing the adaptation strategies for improved community livelihoods.

2.3 The trends and challenges of climate variability (Global, Regional, and Local)

2.3.1 Global Trends and Impacts of observed and projected climate variability.

The global Climate change observations and projections depend on representative concentration pathways (RCPs), including scenarios representative concentration pathways (RCP4.5) and representative concentration pathways RCP8.5. RCPs are four greenhouse gas concentration courses accepted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) (IPCC, 2013). Representative concentration pathways (RCP4.5) explore an appropriate model level of reduction of greenhouse gases in the atmosphere, leading to shifts in climate patterns worldwide. The results in increased changes in climate events at the regional and global levels, and this explores the fact that RCP4.5 is more of an optimistic scenario, and RCP8.5 is perceived mostly in a "business perspectives" scenario in terms of carbon dioxide (CO_2) emissions (Riahi et al., 2011).

Historically, global climate trends have been essential for understanding both current and future climate variability. Numerous studies have explored significant variations in worldwide climatic patterns in the previous years. For instance, the Intergovernmental Panel on Climate Change (IPCC) has consistently reported a rise in global average temperatures, alongside variations in rainfall patterns and the incidences of unpredicted weather events (IPCC, 2014). The global trends are recorded at regional levels and international levels, including East Africa and Africa at large, where temperature increases and altered rainfall patterns have been observed (Niang et al., 2014).

2.3.2. Impacts of Climate change on crop production.

The Intergovernmental Panel on Climate Change demonstrated empirical evidence for rapid and increasing climate variability, including global temperature rise and global warming since the 1970s, as well as the reduction in the size and depth of Arctic ice in recent years. It is estimated that about 17 cm of the global sea levels have risen in the last 100 years, which is worse compared to the past centuries (IPCC, 2007). Various studies have shown these extreme events to exert serious and severe impacts on agricultural systems. It is estimated that about ten times of the recently fertile land for crop cultivation estimated as susceptible to climate variability in the midcentury, which are exacerbated with the increase of carbon emission in the environment, termed as high-emission scenarios of the IPCC's 6th Assessment Report on Climate Change (IPCC. Climate Change 2021). Rising climatic events may coincide with simultaneous weather and climate extreme events, which would regularly

increase, leading to concurrent vulnerability, primarily in agriculturally enhanced areas. Approximately, over 70% of the global poor community, who entirely rely on farming and directly rely on the physical environment their survival, will be severely affected by the effects of climate change and climate variability (Abraha, 2015)
Basing on the result of anthropogenic activities, such as indiscriminate and massive tree cutting for commercial purposes, the effects of climate change have been physically experienced worldwide from through increased greenhouse gases in the atmosphere, leading to global warming and rising temperatures (Vijaya Venkata Raman et al. 2012).

Several impacts of climate variability have taken place worldwide, as witnessed by increased temperatures, altered precipitation patterns, and extreme weather factors, including prolonged dry spells, erratic rains, and the occurrence of cyclones, landslides, and mudslides. The results of such occurrences of climate change events affect crop production and generally the agricultural systems worldwide, and other sectors such as fisheries, animal industry, loss of human lives, wildlife, and affect infrastructural development (Asaduzzaman et al., 2010). Due to climate change vulnerabilities, there might be inadequate or limited cereals to provide essential nutrients, including minerals, carbohydrates, vitamins, and proteins, which are crucial for human life (Elbehri et al., 2011). In addition, agricultural communities in less developed countries experience a consistent increase in prices for agricultural cereals, unlike those in more developed countries. By estimation, the world population is likely to be about 10 billion people by 2050.

2.3.3 Climate Variability in East Africa and Uganda

The East African region experiences two distinct seasons of precipitation, linked to solar heating patterns and the equinox seasons, as well as the geographical landscapes influenced by the air masses in form of wind directions (Cook et al., 2013). The rainfall distributions in eastern Africa and Uganda, in particular, are associated with the Inter-tropical Convergence Zone (ITCZ) and help in enhancing precipitation patterns in the East African countries. The East African nations are along the equator, where two seasons are attributed to the sun's passage over the equator three times annually, which induces this region to have a bimodal rainfall regime. The study shows that out of the two rainfall seasons, rainfall season one begins in March to May, and season two of the rainfall runs from October to December every year, despite other factors including both the north-easterly and south-easterly winds from the Indian Ocean (Ogallo, 1988; Mutai et al., 1998).

In Uganda, especially some parts of northern Uganda, the trends amidst the first rainfall season and the onset of the second rainfall season are very short and make rainfall insignificant and uni-modal compared to the regular bimodal precipitation patterns (Mubiru et al., 2012). To emphasize this, the uni-modal precipitation patterns in this region result from the orographic effect emanating from the extreme weather events of the water sources. The areas adjacent to the equator always have the standard rainfall patterns, and their patterns are uni-modal systems, farthest away from the equator. Further still, long dry spells often run from December, January and February respectively. Climate variations are reflected in terms of long dry spells, extended heavy rains, variations and scheduling for onsets and ending for precipitation patterns, erratic precipitation among others (Conway et al., 2005; Asadullah et al., 2008).

Climatic variability studies for Uganda and eastern Uganda in particular for instance, in the Teso sub region through the umbrella organization called Climate Change and Rural Institutions (CCRI) in collaboration with various institution of learning such as Makerere University have carried several studies for occurrence of climate variability including suggestion of appropriate adaptation strategies (FAO, 2010). The research studies further showed that climatic variables in the country are mainly influenced by the equator; hence, equatorial characteristics enhance the reasonable, moist, and hot climatic features the whole calendar year. The country experiences double main precipitation seasons throughout the year (FAO, 2010).

The predicted variations are expected to be little more plus and sometimes less than 10 per cent of the recent rainfall projected. It should be noted that the prediction in terms of little precipitation is always expected to be received in most of Uganda, precipitation total amounts is likely to reduce to 20 per cent according to current levels along Lake Victoria and Kyoga basins, and predicted Temperatures always increase in the March, April and May to June, July and August (MAM and JJA) seasons in compared to December, January, and February to March, April, and May (DJF and MAM) seasons respectively (Apuuli et al., 2000).

2.3.4 Climate patterns and variability in Uganda and the eastern region.

Uganda's historical climate data indicate notable shifts in both temperature and precipitation. According to the Uganda National Meteorological Authority (UNMA), average temperatures have increased by approximately 1.3°C between 1960 and 2010, through the maximum substantial heating taking place mostly in dry season. Likewise, precipitation patterns have become unpredictable, with increases of intensity and frequency of extreme weather variables, coupled with prolonged dry spells. These trends have profound impacts on wetland agricultural production, particularly in areas heavily reliant on rain-fed agriculture (UNMA, 2015).

Climate variability in Uganda is forecast in mostly on temperature rise and precipitation patterns over time by the Department of Meteorological Services in the Ministry of Water and Environment. For example, precipitation is gradually reducing, erratic, acidic and unpredictable throughout the country. Climate variability in the country, particularly especially eastern Uganda, have significantly affected rainfall distribution across different seasons. Uganda’s climate trends and variations in rainfall patterns are based on forecast data from the responsible institution. However, various studies in Uganda indicate that precipitation patterns are erratic, acidic, unpredictable and not appropriately distributed (Nabikolo et al., 2019).

According to National Environment Management Authority Uganda (NEMA) (2008). The rise in amounts and regularity of precipitation, flooding, mudslides especially mountainous areas and occurrences of related aquatic diseases related to frequent flooding are always seen and confined by community consultation assessment a few years ago were observed unpredicted beginning and ending of precipitation periods. (Ministry of Water and Environment, 2010). The trends were monitored long dry spell regularly being received by the farmers. El Niño Southern Oscillation (ENSO) and other extreme weather proceedings were always detected as little and often more unreliable (Nsubuga, F.W.N., et al (2014c). Research of potential fluctuations in the strengths of mean and heavy rainfall amounts in Eastern part of Africa was carried out Nicholson, S.E. (1996). They further reveal that ‘confirmation for enhancement for the future progressive change in the precipitation circulation amidst global warming are always revealed by the many models, through a one-time model revealing an observation to little raindrops. The study further concludes that ‘It is substantially significant, therefore, to finalize towards the ocean environment comprising design that worldwide heating would improve the probability of anomalously strong little showers’ (Shongwe et al, 2010:3728f).

2.3.5 Key climate drivers (ENSO, ITCZ shifts, temperature, rainfall anomalies).

Climate change variables that is, temperature and rainfall patterns in the country, are enhanced through various factors, including the Inter-Tropical Convergence Zone (ITCZ) (Ngoma, H. 2021). The parts crossed by the equator may therefore experience risky climate proceedings, such as winds, floods, besides droughts, by way of the impact of human-induced activities. This may lead to variations in precipitation in diverse amounts of Uganda. Annually, on average, the total amount of rainfall received in Uganda is about 1200 mm Phillip et al. 2000) By way of a consequence of Weather modification, the regular influence of these rainfall factors has been seriously affected. Uganda's records on climate drivers are still inadequate due to inconsistencies in station records, which in turn affect daily records on rainfall cessation and onset. Accurate and daily availability of copies of the cessation besides beginning of precipitation patterns remains needed towards understand the impacts that could occur. Start and end periods could be affiliated by the significant methods to enhance regional weather conditions, including El Niño Southern Oscillation (ENSO), hurricanes and torrential rain (Mubiru et al., 2012)

Gradual shifts in temperature in Uganda are reflected in the increase in long-term mean temperature. The drivers of increased temperatures include indiscriminate tree cutting, wetland degradation, in addition the accumulated fossil fuels, among others. In Uganda, the worst rise in temperatures is recorded in the north-east sub-regions, especially little temperatures occur in the southern region. Studies have explored the importance of relating next-ground heats to the effects on water sources, particularly the flowing water in lakes and rivers in Uganda. For example, the upper Ssezibwa catchment of Uganda experienced the highest temperatures in 1990s onwards. It was an indication that Uganda had appropriate trajectories in both lowest and extreme temperatures for the series of 1960 to 2008 in Uganda (Nsubuga et al., 2014b).

In terms of Rainfall patterns, Uganda has always received erratic rainfall and this resulted into variations in precipitation patterns have received differently in various areas in the country, for example, some areas receive much rains in form of floods hence leading to various damages including damage to property and people lives alternatively, some places in Uganda have always received long dry spells in form of droughts. It should be noted that throughout the year, Uganda receives rainfall differently in different places, and this either delays early planting of crops or definitely delays the harvesting schedules (Mubiru et al., 2012).

2.3.6 Relevance of Climate Patterns in Eastern Uganda

Climate change patterns in Uganda occur contrarily in diverse areas of the country side and majority under regions and the country are susceptible toward climate change and climate variability for example, areas surrounding Lake Kyoga basin and its management zones including river Mpologoma and lake Lemwa in Bukedi sub region, similarly, the Mount Elgon sub section remains unique for climate change vulnerability for example. Severe extreme weather events, including landslides, mudslides and frequent floods in its plains, and sometimes long dry spells, which worsen vulnerabilities to the adjacent population, especially loss of lives and property. Most of the studies have concentrated on precipitation patterns in places around Lake Kyoga basins and have revealed shifts in the precipitation patterns for many years while some studies concentrated on the increase of carbon amounts in the atmosphere in form emissions including greenhouse gasses accumulations through indiscriminate cutting of trees and encroachment on wetland (Eike, et al., 2014).

Nevertheless, statistic on climatic variability at the national-level are helpful in understanding the climate change trends for Uganda, inadequate literature is available especially on climate changes at locale most especially in Bukedi sub region which helps in enhancing adaptation strategies for the vulnerable local population including crop farming which is the back born of Uganda as a country. Hence, more studies are needed on climatic variables are always experienced at the grassroots levels aimed at identifying and application of appropriate adaptation suitable for such areas or sub-regions. It should be noted that from 2001 to 2011, the average temperature in Uganda rose by about 1˚C; hence Bomuhangi et al., (2016) there could be a warning of climate change in the Bukedi sub-region in relationships to long dry spell and erratic rainfall in the coming years (Bomuhangi et al., 2016).

Climate variability, as enhanced by climate variability factors including both Temperature rise and precipitation patterns, impacts crop production in Uganda, particularly in eastern Uganda. This, in turn, affects crop species diversity due to their global geographic diffusion, which is influenced by temperature, precipitation, and other extreme weather factors (Rosenzweig & Tubiello, 2007). Global Warming is evident through seasonal, annual, and decadal temperatures, as well as precipitation patterns, and erratic weather extremes such as wind, humidity, drought, and floods, which impact farming activities and overall production. The climate change trends always impact the crop propagation through photosynthesis for proper crop growth (Egeru et al., 2014).

Literature has revealed that climate change patterns also influence the agro climatic indices, associated with warming temperatures impacting the proper crop growth seasonally (Turyahabwe et al., 2013; Epule et al., 2017; Bernstein et al., 2008). Climate change events also being attributed towards the adverse effects on the crop farming population, especially wetland farmers, leading to poor crop yields during crop harvesting due to a shortage of appropriate adaptation strategies (Epule et al., 2017; Stocker et al., 2013). The impact is more severe for the farmers depending directly on rain water crop agriculture (Lwasa et al., 2014).

3.3.7 Rice Production in Wetland Agro ecosystems

3.3.7.1 Importance of Rice in Uganda's Agriculture

Rice growing is a vital crop for both household and commercial purposes, serving the local, national, and international population through rice farming production for consumption. Rice production in Uganda is experiencing tremendous growth due to the government's continuous emphasis and support for the agricultural sector, particularly upland rice cultivation. Locally, rice crops support and improves healthy amongst the people through improvement of people's immunity, reduces malnutrition and improves the socioeconomic welfare and standard of the people through sale of rice for income earnings to support facilities including education, well-being, hygiene and health, enhance rural urban development by the households in Uganda (Bigirwa et al., 2013).

Rice farming is also part of the agronomic farming and household food sustenance is vital for growth and development of Uganda through increased Growth Domestic Product (GDP); hence, rice leads to vital for food supplement to the available foodstuffs at the household levels and the country at large. However, as a result of increasing imparts of climate change and the ever-rising world population, Uganda's rice production is facing serious financial and community issues for hindering its support for massive production. This, therefore, calls for immediate adaptation strategies by small rice farmers and the local government to initiate and implement mitigation measures, ensuring sustainable rice farming to support the ever-increasing global population growth (Bigirwa et al., 2013).

Urgent provision of Adaptation mitigation measures to enhance the tremendous rice production in Uganda is important, and such adaptation measures include: early and timely rice land preparations, planting and harvesting to increase on rice yields, use of irrigation systems in order to ensure rice cultivation throughout the year, and provision of improved and better rice seed varieties. Improvement of the agronomic practices enhances and reduces negative impacts of climate change and variability events on rice production for the country. However, rice farmers face climatic challenges sometimes beyond their levels when trying towards sustenance to climate changes for example inadequate financial support from government and limited land ownership especially by women and the youths and this in long run worsens the socioeconomic vulnerability to such farmer categories and this reduces and affect food security at both individual home and community points (Bigirwa et al 2013).

2.3.8 Government initiatives to promote rice farming (Upland Rice Project, NAADS).

The government of Uganda, through the Local governments, especially at the district levels, take precedence over other institutions that is appropriate to help the farmers, including local rice farmers in adjusting to climatic variable issues. To effect these strategies, government of Uganda embarked on a complete devolution programme in 1993 which took the established administration departments at lower local government stages to elected political leaders, civil servants and management staff. However, as a result of the decentralization process, sectors and structures were empowered to take on the mantle of helping the rural poor adapt to climate change events. It should be noted that most of the climate change management policies are still implemented directly by central ministries and NGOs using project-based parallel structures (UBOS 2004)

According to the National Development Plan III (NDPIII) of 2020/21–2024/25 of Uganda it shows that the amount of food to the people in Uganda is insignificant where by about 1.4 million of the population is not having enough food although Uganda is well gifted by natural resources, it was noted that Uganda stands at 37% of food energy shortage as reported by the world food program that a substantial number of people in Uganda are underfed. It should be noted that approximately 86% of Uganda's inhabitants lives in the villages besides they depend on subsistence agriculture who rely directly on rainfall; hence, this induces them to produce fewer outputs in terms of crop production. The vulnerable farmers in the country are below the poverty line, and they cannot have a dollar on a daily basis (Karanja F, et al. 2001).

2.3.9 Wetlands and Rice Farming Systems

2.3.9.1 Agro-ecological benefits of wetlands for rice production

Wetlands provide numerous benefits in the form of resources and accruals both native communities for broader community members adjacent to wetlands and their peripheries, particularly through farming practices such as paddy rice cultivation. At the national level, wetlands support various enterprises, both tangible and non-tangible, for several stakeholders, for example, support to dry season agriculture through irrigation, water for home consumption and commercial use. Water for livestock, and provision of wetland accruals including aquatic resources rice, tomatoes, hunting, eco-tourism, medicinal purposes among others (Chombo et al., 2018).

Approximately 80% (F. Karanja, L. et al, 2001). of the population near wetland places in Uganda use wetlands for farming purposes, especially rice farming, and accrual of resources for their home consumption and commercial purposes, such as the sale of papyrus mats. Rice farming in wetlands provides the population with food for a considerable period, leading to socioeconomic benefits, including increased incomes from rice sales, and promotes nutrition through adequate food consumption. Rice is a farming crop for food security, which ensures the continuity of food supply required to sustain the population, the amount needed and consistency as demanded by the people. Uganda is well endowed with Agro-ecological benefits of wetlands, especially rice production, which is supported by ten agro-ecological zones classification (National Agricultural Research Organization (NARO). 2010). Such implication at the national, regional and global information use is essential to the local farming systems, including rice production (Stampone et al., 2011).

Wetland rice grown is a significant food staple and a key commercial crop for the majority of farming community members in the local environment and Uganda in particular. Wetland Rice grown in Uganda is increasingly demanded in Africa, the Americas, and worldwide ((FAO, 2017; GRiSP, 2013) Indeed, the wetland rice is crucial as a household staple food and, at the time, considered a cash crop especially the village and towns in the country. Rice is among the crops in the country vital meant for food safety and helps in poverty improvement for vulnerable indigenous people. In 2014, about 350,000MT of rice has been produced in Uganda, as compared to the demand of 450,000MT per year Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) (92010). Food and Agriculture Organization of the United Nations, globally, rice production and consumption expected to be used by 3.5 billion people by the end of 2025, and these projections are based on the current massive rice demand due to its importance in socioeconomic and food consumption worldwide (FAO, 2010).

In Uganda, wetland rice farming began in 1904 (Uganda Bureau of Statistics (UBOS). (2004). however, the massive expansion of wetland rice growing attracted various farmers in towards the end of 1990s Uganda Bureau of Statistics (UBOS (2004). During this period, population mainly cultivated wetland rice for home consumption, and basically, individuals cultivated rice through subsistence practices only. The Uganda Bureau of Statistics states that the wetland value chain provides necessary avenues to ensure wealth creation amongst the various stakeholders, and these include: farmers, transporters, millers, traders, hence, leading to a tremendous Growth Domestic Product for Uganda (UBOS 2004).

Uganda's wetlands support approximately 2.7 million individuals directly and over 4 million individuals supported in one way or another by the wetland stakeholders through the accrual of various wetland materials for both consumption and commercial purposes (Waswa & Satognon, 2020). People living adjacent to the wetlands typically rely on wetlands for their day-to-day survival through wetland farming, the use and harvesting of wetland resources, coupled with many impacts of climatic changes which affect socio-economic and ecological functions of wetlands (An & Verhoeven, 2019).

The approximation of about 36% of wetland coverage, especially in eastern side of the country including Limoto wetlands were turned into farmland between 1994 and 2014. The phenomenon of wetland crop cultivation, which has been so common in eastern Uganda, including Limoto wetlands in Kibuku District, is because in these wetlands local community members have taken wetland rice farming intensively, especially for commercial purposes (Namaalwa et al., 2013).

Wetlands in Kibuku district are increasingly becoming important and have attracted intensive rice farming. It should be noted that rice farming in wetlands in Kibuku has led to urban growth, especially along the peripheries of Limoto wetlands, which is a tributary to Great Mpologoma River in Kibuku District, eastern Uganda. By way of consequence of climate change and variations brought about through negative human behaviors including indiscriminate tree cutting and wetland water channeling, these wetlands and swamps dry up, impacting crop production, especially rice, leading to community vulnerabilities to surrounding communities through famine and continued poverty (Mombo, 2017)

Wetlands in Kibuku inhibit soils mostly eroded from the catchment areas adjacent to the wetlands, which are so fertile and enhance crop production, especially rice production. The continuous and improved wetland cultivation leads to the improvement of people's welfare while supporting the ecosystem functionality. Wetlands in Kibuku district, including Limoto and Mpologoma, have supported the nearby population and Uganda as a whole in terms of food production, due to Uganda's rapid population growth, which is 3.32% annually (UBOS, 2020). Various enterprises by various stakeholders are accrued from Uganda's wetlands for various purposes, including both consumption and commercial gains (Barakagira & de Wit, 2017). There are many Ugandan farming either in wetlands or at the wetland peripheries and this contributes to Uganda's Gross Domestic Product.

Despite the availability of much climate data globally, a wide gap of information on the link between climate variability and rice production in wetland areas for the long-term datasets, particularly in less-studied areas. This gap affects the acquisition and recording of appropriate data on the effects of climate variability on rice production and other agricultural practices. Most research tends to concentrate on minimal information on climate and weather events which relatively support crop health and productivity. This gap can be bridged by analyzing various climate variables and their impact on rice production, a task that is feasible with historical data. Therefore, the research investigated long-term climate trends around wetland areas, particularly the Limoto wetlands. This approach not only enhanced the applicability of information but also guaranteed temporal dynamics of climate variability were accurately captured (Field et al., 2012).

2.3.10 Ecological constraints and environmental degradation.

Wetland rice farming globally faces various challenges amidst climate change and climate variability. Wetland degradation through encroachment by rice cultivation is one of the cardinal constraints which impacts both the population and environment, as a result of climate change events at both global, sub-Saharan Africa, and local levels. Therefore, due to climate change events such as drought and/or floods, there be inadequate food production which can lead to famine. Climate change and variability impact crop production and hinder access to sustainable, abundant food (Kansiime et al., 2013).

Wetland rice production relies on rainfall for its farming, and this exacerbates its susceptibility to climate change events. The reduction in rice production has adverse multiplier effects and this increases the consequence of vulnerability to extreme weather events (Kijima et al, 2012). Climate change and variability events pose significant threats to crop production growth and development in Uganda, impacting crop value chains and ultimately disrupting demand and supply trends. Persistent rise in temperatures, shifts in rainfall trends and extreme weather events affect crop growth, increase transport costs and affect demand and supply chains. This has worsened vulnerability to the population, leading to an increase in commodity and food prices. (Dekens & Bagamba, 2014).

Climate change issues in Uganda are manifested through erratic rainfall patterns and weather proceedings including long dry spell and heavy rainfall. One of the severe concerns of climate change and variability is the rise in temperatures, changes in precipitation, low levels of water, and increasingly common weather events including temperature and flooding issues, which affect crop production, leading to food insecurity amongst the world population. Recently, extreme weather events, including strong winds, hailstorms, droughts, and floods, have become increasingly prevalent due to climatic changes and variability, severely impacting agricultural production (Ministry of Water and Environment, 2002; Okonya et al., 2023).

It should be emphasized that with suitable adaptation actions on the consequence of climate change, agricultural practices with accurate systems requires stakeholders to come together to explore the best adaptation strategies for appropriate management of climate variability events. However, some of these issues are faced by the policymakers and policy implementers through diversified law and policy enforcement of such laws and policies. The human induced activities and natural occurrences are a result of climate variability can impact positively or negatively on the atmospheric processes globally, various research on global climate change and variability especially on their effects on the socioeconomic and ecological resources including crop production, water production, and trade, and the entire community development, this exacerbate vulnerability most especially to the indigineous people who solely depends on the rain water for farming (Bomuhangi, Nabanoga, Namaalwa, Jacobson, & Abwoli, 2016).

Several studies exploring global, regional and local climate change and variability (Nsubuga, F. W., et al (2014). Indicate that temperature is increasing, and precipitation are erratic similarly same way as the weather extreme events, especially droughts and floods. The global predictions (Bomuhangi et al., 2016) depict the rise in transformation from an absolute poverty-prone population to a wealth-creating population by 2030 in line with the Sustainable Development Goals (SDGs) agenda. However, all the above strategies are exacerbated by climate change and climate variability. Furthermore, agricultural systems are available for sufficient water for crop production especially susceptible to variations in climate events, as their survival largely depends on climate change variables, such as temperatures and rainfall patterns (Bomuhangi et al., 2016).

2.3.11 Climate variability and Rice Yields

2.3.11.1 Effects of temperature rise, erratic rainfall, wet, and dry events on rice farming.

The global temperature projection is bound to increase from 2.5 degrees Celsius to 4.5 degrees Celsius as a consequence of the rise in emissions due to the accumulation of greenhouse gasses into environment by 2100. Climatic variability affects the environment globally, for instance, loss of ecosystems, and soil fertility exhaustion, leading to slight and insufficient agricultural production (Osborne T, et al, 2013).

Empirical evidence shows that climate change worldwide constitutes a significant issue faced by humanity and their ecological environment, wellbeing, food basket and their lives in general (Clarke et al., 2012). Both wealthy and impoverished countries have their economic characteristics, which are disrupted by climate change issues. For instance, poor countries and their people face more vulnerabilities to climate change. Village farmers mostly for the most African countries at risk of vulnerabilities to climate change. It is estimated that over 95% of crop farming in Saharan countries depends entirely on rainfall (Adger et al., 2003).

Studies of climate in Africa indicate that substantial changes are expected, including prolonged dry spells that may lead to warming in sub-Saharan Africa, accompanied by significantly increased rainfall patterns (Christensen et al., 2007). The major issue in climate change replicas especially circumstances in Africa yet, they reflect a bit of complicated especially regarding changes in precipitation happening as the climate changes. Almost all methods show a warming Southern Africa and unworthy for predictions in some areas, especially West Africa (Christensen et al., 2007).

Various research has been conducted on climatic variables globally (IPCC, 2014). this has explored much assurance indicating how the agricultural production including wetland rice farming can be constantly and severely damaged as a result of climate variation in years to come especially the countries around the equator, and alternatively the climate changes would pose good or bad impacts mostly in the northern hemisphere (IPCC, 2014Similarly, some regions may have favorable conditions, including health, agricultural yields, increased soil fertility, and sufficient water for consumption, which could impact the continuity of wetland rice farming systems in these wetlands. IPCC also predicted most of the agricultural yields of crops such as wheat and rice are likely to decrease approximately by 17 per cent worldwide by the year 2050 as compared to a situation with favorable climate change (IPCC, 2014).

In managing climate variability, it is essential to ensure sustainable use of scarce agricultural resources for future generations. This requires suggesting realistic strategies to achieve sustainable development in agricultural production, thereby mitigating the projected impacts of climate variability on future generations. IPCC reveal that climate variability adaptation strategies are enhancements to the ecosystems in order to prevent the severe effects related to extreme weather events (Osbahr et al., 2011). It further shows that diverse areas may have diverse ways vulnerability to climate variability, especially in agricultural production. This is the reason that has led various researchers to explore the severity of climate variability on diversified agricultural mechanisms, especially according to regions, through the use of numerous agricultural crop models and climatic methods with numerous emission scenarios. Nevertheless, climate events are causing a shortage of available food compared to the rapidly increasing number of people globally (IPCC, 2014).

However, a deeper understanding of climatic events and their occurrences is crucial, particularly in terms of their impact on agricultural and animal production, and the suggested approaches for climate variability adaptation. These insights enable village farmers to utilize locally available knowledge of solving expected effects of climate change. Different scholars have deemed the villagers' ideas inadequate for truly revitalizing the vigorous climate adaptation plans (Nyasimi et al., 2013).

2.3.12 Studies on rice production losses and seasonal disruptions.

Globally, crop replicas are important methods in determining farming yield for sustainable use, particularly in the face of present and future climatic changes. Such representations associate extreme events with agricultural crop yields in an appropriate functional way. Nevertheless, the agricultural and crop reproduction are always met with several challenges for example, the real environment from the crop farming fields, for instance the impact as a result of pest and disease prevention and control in some conditions especially those that relies on farmer's performance and the management practices applied to such situations (Kassaye et al., 2021).

Among the significant effects of climate variability on rice crop yield losses is the uncertainty surrounding adoption of the crop to weather events including long dry spell. This uncertainty disrupts timely planting and, consequently, impacts the timely harvesting of crops. The accumulation of greenhouse gases resulting from wetland degradation and extensive tree cutting leads to greenhouse gas effects, ultimately causing ozone layer destruction. This, in turn, results in erratic and acidic rainfall, damaging crops, including rice production (Lobell & Gourdji, 2012).

2.3.13 Study findings from East Africa and Uganda.

Study literature on climate change shifts were explored from various areas across Uganda. Therefore, climate change trends and variability have been evident in terms of rainfall patterns, for example, in the districts of Kibale and Kisoro (Stampone et al., 2011). It is evident that the periodical occurrence of seasonal precipitation in western Uganda is heterogeneous within the same zones and very diverse amongst sites, stations, and meteorological trends in annual precipitation, differing only in scale and course from the seasonal patterns (Nsubuga, Olwoch, & de Rautenbach, 2011).

Climate variability affects rice production over fluctuations in temperature including precipitations (Mendelsohn, 2008; Rosenzweig et al, 2001). These changes have negative implications for agricultural practices, crop harvest, and food safety, especially for areas where small wetland farming systems dominate and are heavily reliant on natural weather patterns (Bates et al., 2008). In Uganda, a shift precipitation and rise in temperature patterns mstly in the past periods has been realized, hence impacting crop production (Nsubuga et al., 2014). Nonetheless, there is still a noteworthy gap in targeted investigation that connects these climatic trends with local impacts and responses in wetland production areas (Nsubuga et al., 2014).

There is information on famer’s perception and respond to climate variability during rice production in wetland areas. However, there is little understanding of how rice farmers in wetland areas such as Limoto Wetlands adapt their rice production amidst climate change. Adaptation strategies together with socioeconomic features show a critical part for influencing paddy rice production amidst climate variability (Bryan et al., 2009).

Analysis of historical changes in climate variability factors including temperature, precipitation, and speed among others is crucial on behalf of underscoring the effects of climate variability on rice production, mainly for the sensitive ecological zones including wetlands. I globally crop farming settings, extensive investigation has documented significant shifts in these variables, indicating a trend towards increased climate variability and change (IPCC, 2014?). For instance, studies have demonstrated that temperature increases have negatively affected crop yields in major agricultural regions by altering growth rates and water usage patterns (Lobell et al., 2011).

The connection amongst climate variables and agricultural production for a long time widely investigated across various geographical settings. Research has consistently shown that variables such as temperature, rainfall, and humidity significantly influence agricultural outputs, particularly in crop-specific contexts like rice production. For instance, Welch et al. (2010) documented how temperature fluctuations affect rice productivity, impacting yield potentials.

Similarly, it was analyzed on the global datasets and found that precipitation variability is closely correlated with anomalies in rice yields, emphasizing the sensitivity of rice crops to water availability Welch et al. (2010)).

In wetland areas, where rice cultivation heavily depends on rain-fed systems, these climate variables play a pivotal role. Studies from similar ecosystems in Asia, like the Mekong Delta, reveal how changes in river discharge patterns, influenced by both climatic factors and upstream water usage, directly affect rice production in downstream wetlands (Kummu & Sarkkula, 2008).

Despite the increased research on climate impacts on rice production, there are still knowledge gaps in research that links both spatial and temporal information to give a profound revelation of the climate variables, especially at the local scale. Most studies provide a broad global perspective, but lack records for local settlements. This approach can obscure important local and temporal variations that are critical for developing effective adaptation strategies, especially in diverse ecological settings like the Limoto Wetlands (Ayanlade & Drake, 2016; Mertz et al., 2009).

In wetland areas, which are important for rice production changes in these climate variables can have profound effects. For example, the study in the Tana River Delta has shown that variability in rainfall patterns has led to either extreme drought or flooding, both of which significantly affect rice yields. These studies demonstrate the delicate nature of rice production, highlighting how even minimal changes in climate factors can significantly impact rice production and other agricultural systems (Field et al., 2012).

Notwithstanding the availability of generalized climate data, a notable deficiency among region-specific long-term datasets, particularly in less-studied areas such as those in Eastern Uganda. This gap hinders the ability to accurately predict and prepare for the specific impacts of climate variability on local agricultural practices. Many scholars are likely to emphasis on a narrow set of climate variables, often overlooking other factors that also significantly influence crop health and productivity. This narrow focus may lead to incomplete understandings of the complex ways in which various climate factors interact to affect agricultural ecosystems (Field et al., 2012).

By incorporating these diverse climate variables, this study allows for a more holistic understanding of their impacts on rice production using Limoto Wetlands as a case study. By identifying specific trends and patterns, this study can contribute valuable insights that will aid in the development of adaptive agricultural practices and policies tailored to the unique climatic conditions of Kibuku District. The findings from this analysis would to help as a by the way of critical resource for forthcoming investigation and decision-making processes aimed at mitigating the impacts of climate variability on rice production (Field et al., 2012).

2.4 Farmers' perceived impacts of climate variability on rice production and its factors

2.4.1 Understanding Farmer Perception

In Africa, small farmers' perception of climate change and variability in the agricultural arena is vulnerable towards its effects, then these include: erratic weather conditions, long dry spells and rampant floods. Several studies have explored that in sub-Saharan Africa, especially the East African countries (Igodan et al., 1990; Mendelsohn, 2006, 2008; Esham et al., 2013), are more affected by severe climate change issues than other African regions. This is due to inadequate adaptation practices, low levels of appropriate climate change mitigation measures and a vicious cycle of poverty in sub-Saharan Africa. Inappropriate ability to take adaptation strategies into practice has been a challenge towards climate change management and exacerbated the global food insecurity, leading to famine in several parts of the world, with concerns extending beyond 50 years to come (Bagamba et al., 2012).

The rainfall studies and trends over the African continent show that there is an empirically substantial increase in the seasonal, annual and decadal rainfall patterns, especially in most of the parts of and adjacent to West Africa, the Horn of Africa, where the East African Region is located, generally showing a substantially declining rainfall tendency. The main reasons of the inter-annual climate changes in Africa include El Niño Southern Oscillation (ENSO), as a result of the large-scale changes in Sea Surface temperatures (SST) over the tropical Pacific Ocean that influence climatic conditions over much of the tropics and sub-tropics (Omondi et al., 2014).

This should be emphasized that minor crop growers in Uganda consider serious precipitation throughout the first onset period to be short in the local environment and isolated hot and dry events. Long Dry spells are reported to be severely expanding in Uganda (Mubiru et al. (2012). Climate change and variability are always observed in variations in the water levels (Nsubuga et al., 2014a).

Farmers' perceptions of climate change are important for providing effective adaptation strategies in climate-sensitive areas. Studies across the globe have shown that farmers always predict changes in climate variables but handle these changes differently, and this is sometimes influenced by local environmental factors (Grothmann & Patt, 2005; Maddison, 2007). For example, in sub-Saharan Africa, most farmers are aware of shifts in climate patterns; their perceptions were based on indigenous knowledge and personal experiences from the climatic changes they face (Mertz et al., 2009; Silvestri et al., 2012).

2.4.2 Farmers' Perceived Climate Risks in Rice Farming

The evidence shows that climate change and extreme weather events including are widespread. For example, beginning and end of precipitation remain so unreliable, then it is projected that extended wet situations will occur in the years to come. Long dry spells and increased precipitation are common extreme weather events in the eastern districts of Uganda (Bomuhangi et al., 2016).

In south-west Uganda, for instance, farmers' perception of climate trends and variability mostly depends on available indigenous information to predict whether it will be drought or extended rainfall in the following seasons, so that agricultural plans can be done accordingly. Regarding the extreme weather events, for example, drought, this has presented severe annual impacts some time back, and it is projected that the country is likely to have shifts in precipitation patterns, indicating that the second season for precipitation is likely to be much more intense (Ministry of Water and Environment, 2007).

Several investigations conducted to study how the farmers perceive the effects of climate change (Mubangizi et al., 2017; Bomuhangi et al., 2016; Mugagga, 2017). The scholars show how farmers sometimes predict actual information locally to suit the climate change, especially the drought and floods which this helps them in suggesting appropriate practice for adaptation strategies which are always locally available. However, it is noted that various factors sometimes enhance farmers' perceptions of climate change, including socio-economic factors, which differ from one place to another (Mugagga, 2017).

Elsewhere, in the Mekong Delta, for instance, research has shown that rice farmers' perceptions of climate variability significantly influence their decisions on crop selection, water use, and investment in irrigation technologies. These perceptions are identified by observations of changes in precipitation patterns and temperature fluctuations, which definitely affect crop yields and the overall agricultural productivity (Tran et al, 2018).

Despite the various research on farmers' perceptions of climate change on rice production, there remains a notable gap in research focusing on how these perceptions specifically affect agricultural decisions in wetland-based rice production systems. Consideration of various characteristics of wetlands that may influence farmers' perception and adaptive strategies is very important (Van Aalst et al., 2008). There is a gap that monitors changes in farmers' perceptions over time, and which is important in understanding growing adaptation needs and strategies amidst ongoing climate change (Below et al., 2012).

The example of Limoto Wetlands, Kibuku District, provides a similar case for identifying these climate changes due to its different hydrological and ecological characteristics that directly impact wetland rice production. The valuation of the farmers' perceptions of climate change in Limoto Wetlands can bridge the identified gaps by providing a consideration of how farmers' perceptions of climate variability relate to adaptive approaches in wetland rice production. This approach will not only enhance the understanding of the socio-economic and cultural strategies of climate adaptation but also contribute to the modern rice farming practices that are beneficial to local communities (Bryan et al., 2013).

2.5 Factors influencing effectiveness of adaptation to climate variability on rice farming

2.5.1 Climate change agricultural adaptation definition and relevance

Agricultural Adaptation is defined as the adjustment in socioeconomic and environmental structures in reaction to real and predictable effects of climate change and variability in association through non-climatic changes. Agricultural adaptation ranges after temporary managing strategies to permanent full-scale controlling in order to attain more diversified objectives, which either do not achieve a substantial effect or misuse valuable chances (Moser & Ekstrom, 2010).

Agricultural adaptation" is further defined as the adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects; such adjustments moderate harm or exploit beneficial opportunities (IPCC, 2014a). Agricultural adaptation takes place longitudinally and is time-bound, and for adaptation to succeed, the following have to be considered: appropriate technology, socioeconomic empowerment, building institutional capacities, regulating policies, ecosystem conservation, and thorough information sharing, among others (Carmin et al., 2015; Rosenzweig et al., 2018).

Agricultural adaptation helps in decision making; this means that recent decisions are affected through the results for the previous human activities (Ehrhardt-Martinez, Rudel, Norgaard, & Broadbent, 2015). In the same vein, the factors for increased emission of carbon dioxide leads to accumulation of greenhouse gases globally; however, the severe effects of climate change and climate variability are felt locally, particularly in the low-developed economies (Miller Hesed & Paolisso, 2015).

Agricultural adaptation strategies in wetland rice production in reaction to climate variability have been generally explored, providing diverse approaches aligned to climatic issues by the local wetland farmers. Subsistence farmers in various parts of Africa have been reported to adapt to climate variability through diversification of crops and alteration of planting and harvesting times. Similar to rice farming in the Yangtze River Delta, which showed that acceptance of early-maturing rice varieties and improved irrigation techniques significantly mitigated the adverse effects of delayed monsoons and extended dry spells (Morton, 2007).

The features leading to choice of adaptation strategies vary. According to Deressa et al. (2009), a detailed study of the factors influencing farmers' choices of adaptation strategies in Ethiopia shows the role of access to information, economic resources, and the perceived severity of climate impacts. These studies collectively highlight the complicated relationship among climate variability and the adaptive capacities of wetland agricultural communities. Despite the extensive literature on the effect of climate variability on rice production, the adaptations from small farmers to climate variability remain a significant gap in research involving socio-economic factors and adaptive strategies. Most research tends to focus on socio-economic factors in isolation, without considering how these variables influence farmers' decision-making processes (Eakin et al., 2014).

There is still a need for in-depth research on how small rice farmers in wetland areas adapt to climate variability, focusing on how these adaptation strategies relate to demographic features. Using both quantitative surveys and qualitative interviews, the research would gather data on various adaptation strategies, including diversification to non-crop livelihood sources (Musinguzi et al., 2015). This approach is particularly vital to the understanding of adaptation behaviors and practical outcomes in terms of policy recommendations that are sensitive to the demographic makeup of agricultural communities (Berman et al., 2012).

Modification actions for wetland rice production amidst climate variability have been generally explored, providing diverse approaches aligned to climatic issues by the local wetland farmers. Showed how subsistence farmers in various parts of Africa adapt to climate variability through diversification of crops and alteration of planting and harvesting times. Similar to rice farming in the Yangtze River Delta, which showed that acceptance of early-maturing rice varieties and improved irrigation techniques significantly mitigated the adverse effects of delayed monsoons and extended dry spells (Morton, 2007).

There is still a need for in-depth research on how small rice farmers in wetland areas adapt to climate variability, focusing on how these adaptation strategies relate to demographic features. The research would collect data on various adaptation strategies, including diversification to non-crop livelihood sources (Musinguzi et al., 2015). By exploring new variables that may affect adaptation strategies, such as social networks and local knowledge systems, which have been less explored in previous research, this study would provide an understanding of the socio-economic dimensions of climate adaptation. This approach is particularly vital to the understanding of adaptation behaviors and practical outcomes in terms of policy recommendations that are sensitive to the demographic makeup of agricultural communities (Adger et al., 2009; Berman et al., 2012).

2.5.2 Influencing effectiveness factors (education, gender, extension, farm experience).

Education aims to generate more information and ideas on climate variability, particularly for the population, and encourage them to be innovative and aware of the impacts, vulnerabilities, and consequences resulting from climatic events, and then suggest adaptation strategies. The essence is to empower farmers to solve the future climatic problems through locally available means (Bentley et al., 2019).

Studies have identified and acknowledged the factors influencing gender-related aspects, including poverty, indigenous knowledge, administration, financial aspects and organizations that obstruct them, particularly for females (Pandve et al., 2011). It is important to mention the large number of studies on gender related aspects on changes in climate are handled basing on gender aspects for long-term skills and insights they have on climate change and variability are always observed of gender-based outlook, (Pandve et al., 2011), for instance, females are seen to be more susceptible climate change impacts especially in agricultural society. Women always rely on the rain-fed situation and get resources directly from the environment, hence environmental degradation (Rishi et al., 2011).

2.5.3 Coping adaptation factors of Small Rice Farmers in Uganda

Small rice farmers in Uganda employ a variety of modifications and coping actions to mitigate the effects of climate variability on rice production. These strategies involve both traditional practices passed down through generations and modern approaches aimed at enhancing climate resilience. Traditional adaptation practices in rice production include indigenous knowledge systems and time-tested agricultural techniques that have been refined over the years of experience. Farmers often rely on practices such as crop diversification, intercropping, and mixed cropping to mitigate risks related climate variability (Omondi et al., 2020).

Traditional practices further indicate that small rice farmers in wetlands are increasingly adopting modern adaptation strategies to foster the sustainability to climate variables. These strategies encompass acceptance of climate-smart farming actions including conservation agriculture, combined pest management, and improved soils and water management techniques. By implementing these actions, farmers always reduce on resource use, enhance soil health, and mitigate the effects of climate variability on crop production (Nabikolo et al., 2019).

Community-based adaptation initiatives play a crucial role in supporting small rice farmers in the Limoto Wetlands to adapt to changing climatic conditions. These initiatives often involve collaborative efforts between farmers, local organizations, government agencies, and research institutions to develop context-specific adaptation strategies and build local capacity. Examples of community-based adaptation initiatives include the establishment of farmer field schools, climate information services, and the promotion of climate-resilient crop varieties (Omondi et al., 2020).

2.5.3 Drivers of adaptation factors among rice farmers

Socio-economic factors play a significant role in shaping the adaptive capacities of small rice farmers. These factors encompass various dimensions, including income levels, access to resources, education, and social networks. Studies have shown that farmers with higher levels of education and income tend to have greater access to information, resources, and technology, enabling them to adopt more effective climate adaptation strategies. Marginalized communities with limited access to financial resources, education, and extension services may face greater challenges in adapting to climate change (Nabikolo et al., 2019).

Gender disparities also influence the adoption of climate adaptation actions by the rice farmers. Women, who always leads a crucial part in agricultural production and household enhancement, may have distinct priorities, preferences, and constraints compared to men. Studies have highlighted the importance of gender-related aspects to climate adaptation, identifying the important parts played by women in farming and the need to address barriers to their participation and decision-making. Gender-responsive interventions, this enhances women's access to resources, technology, and information leads to appropriate inclusion in climate adaptation successes in the region (FAO, 2011).

Moreover, marginalized communities, including ethnic minorities, often face additional challenges in adapting to climate variability due to historical, poverty, and financial imbalances. These communities always have inadequate access to land, water, and other natural resources, exacerbating their vulnerability to climate-related risks. However, research suggests that marginalized communities also possess valuable traditional knowledge and adaptive practices that leads to climate adaptation and resilience (Adger et al., 2013).

Empowering these communities through participatory approaches, inclusive policy-making processes, and equitable access to resources can enhance the adaptive capacities and promote more sustainable and just outcomes amidst climate change. Therefore, farmers' insights, long-term climate change trends, and small-scale farmers' adaptation strategies would be critical considerations in understanding and addressing the effects of climate variability on rice production in areas such as Limoto wetlands (Adger et al., 2013).

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents the methodologies that the researcher used during the investigation. It contains; the research design, study population, sample size and selection strategy, data collection techniques, procedure for data collection, data management and analysis, ethical issues and study limitations.

3.2 Research Design

This study followed a mixed-methods design. The trends and challenges of climate variability under Objective 1: used secondary data of both temperature and rainfall from Department of Meteorological services in the Ministry of Water and Environment. In contrast, contemporary data on perceptions of rice farmers on the effects of climate variability on rice production and adaptation strategies under objectives 2 and 3, respectively, followed a cross-sectional design with a one-time sampling. The cross-sectional research design utilised both qualitative and quantitative approaches to investigate the farmer's perception of the effects of climate variability on rice production in the Limoto Wetlands. For the quantitative approach, a semi-structured questionnaire (Appendix 1) was used to collect data from farmers on demographic characteristics (such as, gender, age, marital status, household size, education level, years of rice farming experience, farm size, residence status, and income per season), perceptions of climate variability, past trends in rice yield per unit area, seasonal variations in rice production, farmer's perceived impact of climate variability on rice production, factors influencing adaptation to climate variability by the wetland rice farmers and constraints to adaptation.

The qualitative approach involved a combination of focus group discussions (FGD) and key informant interviews (KIIs) to gain an in-depth understanding of socio-economic factors that might guide rice production and adaptation practices (Denzin & Lincoln, 2018). The focus groups included rice millers, service providers (that is, dealers in fertilizers and pesticides), and the rice traders (wholesale and retailers), while the key informants involved agricultural extension officers and community leaders.

All individual questionnaires were administered using the Kobo Collect tool. Within each sub-county, with the help of the local leadership, three data collectors were selected and trained on the questionnaire. Because the questionnaire was designed in English, individuals fluent in the common local language with a good understanding of English were selected as data collectors to minimize the resentment of respondents due to the language barrier. Accordingly, the questionnaire was administered in the local language.

3.2 Study Population

The population of Kibuku District was 202,033 according to the 2014 census. More recent data from the Uganda Bureau of Statistics (UBOS) for the 2024 NPHC (National Population and Housing Census) provides specific figures for different locations within the district, such as a total of 16,060 in Kibuku town. 2014 Census: 202,033 and 2024 NPHC (Kibuku town): 16,060. The total population of the district is distributed in 25,141 households. In the five sub-counties of the study area, the total population is 113778 which is distributed as follows; Buseta sub-county 16,707, Kadama sub-county 20,119, Tirinyi sub-county 31563, Kirika 23,549 and Kasasira sub-county 21,840 persons. Tirinyi, Kasasira, Kirika, Kadama and Buseta Sub-counties were purposively selected from among the 10 sub-counties in Kibuku district because they are the ones where the wetlands under study area are located.

3.3 Sampling strategies and sample size

Simple random sampling was employed to select respondents in two sub-counties within Kibuku district, which comprise the majority of rice farmers, that is, Buseta and Kituti sub-counties. The sample size was determined using Yamane's formula: $n = N/ (1 + N (e)^2$, where n is the sample size, N is the population size, and e is the margin of error (assumed at 5%) (Yamane, 1967). From this formula, the sample size that corresponds to a population of 900 active farmers is 276. In the field, 279 farmers were interviewed; however, after data cleaning, the number of respondents was reduced to 268, which was considered adequate as it was still comparable to the number derived from Yamane's formula. Of the 268 respondents, 160 were from Buseta Sub-County, while 108 were from Kituti Sub-County. The selection process aimed to capture a diverse cross-section of rice farmers within the study area.

3.4 Data collection for specific objectives

3.4.2 The trends and challenges of climate variability (temperature and rainfall).

Secondary data on monthly temperature and rainfall for the period 1995–2024 were obtained from the department of Meteorological services, under the Ministry of Water and Environment. This period matches a minimum of 30 years, which is recommended for climate change analysis (Fathauer, 2011). These data were from the Mbale weather station, which is the closest weather station to Kibuku District. Data on temperature were obtained as mean monthly minimum and maximum values, while data on rainfall were obtained as monthly totals. These data were supplemented by interview data, collected on perceptions of farmers about climate variability. These data included perceptions of extreme climate events, including the frequency of drought and floods, change in timing of the seasons, and extreme dry and wet years.

3.4.3 Farmers' perceived impacts of climate variability on rice production and the factors that shape these perceptions

Data on past trends in rice kilograms per unit area, seasonal variations in rice production, and farmers' perceived impacts of climate variability on rice production were collected using a semi-structured questionnaire (Appendix 1). From 1960 to the present, climate change trends show a clear and accelerating global warming pattern, characterized by a significant increase in global temperatures, especially since the 1970s, and the most recent years being the warmest on record.

This warming is primarily driven by the human-caused increase of greenhouse gases from burning fossil fuels. The period for which climate data were available (i.e., 1995-2024) was divided into four decadal periods (that is, 1990s, 2000s, 2010s, and 2020s), and each respondent was asked about rice kilogram per unit area during each of the four decadal periods. This approach was used to develop a quasi-temporal dataset on rice production that could be related to climate data, since continuous time series data on rice production were not available. Although individual farmers' perceptions could be inaccurate, this study relied on the "jelly bean jar experiment" or the "wisdom of crowds" experiment by Treynor (1987).

This approach demonstrated that the average of many independent estimates is often accurate, even if individual perceptions were wildly off. This approach has been repeated more recently by Mauboussin (2007). Here, a big jar of 1,116 jelly beans was given to 73 individuals, and their guesses ranged from 250 to 4,100. Whereas the individual error was

62% from the actual value, the average (i.e., the "wisdom of crowds") was 1,151 , just 3% off the actual number. In this study, it is assumed that the average perceptions were closer to the actual value than most, if not all, individual perceptions. The created dataset was, therefore, scientifically valid. To verify the responses on rice production, farmers were further asked about the current rice production, which was expected to be comparable to the value reported for the 2020s. Where significant variations existed, the farmers' responses on this aspect were discarded.

The above data was augmented by qualitative data, also collected through the same questionnaire, where participants were asked about the impact of long dry spell or wet season on rice production. Here, the frequency of responses regarding impacts such as reduced yields, reduced quality, reduced farming areas, disrupted harvesting, reduced income, and poor markets was recorded. For seasonal variation, quantitative data on rice yield per unit area during the wet and dry seasons were collected through the same questionnaire (Appendix 1)

3.4.4 Factors influencing effectiveness of adaptation to climate variability on rice production

Using the same questionnaire **(Appendix 1)** data were collected mainly on demographic characteristics (such as, gender, age, marital status, household size, education level, years of rice farming experience, farm size, residence status, and income per season), adaptation strategies in response to climate variability, enablers of adaptation (such as use of technology and belonging to social groups), and constraints to adaptation. The frequency of responses regarding adaptation, such as early planting, use of early-maturing rice varieties, drought-resistant varieties, irrigation, extending to water-logged areas, reducing the size of the garden, fertilizers, value addition, exiting farming, and diversifying to other enterprises, was recorded. Of particular importance was the collection of data on diversification activities, especially to non-farming enterprises, which has a strong influence on the resilience of farmers to climate variability and change.

3.5 Data Analysis and presentations

3. 5.1 The trends and challenges of climate variability around Limoto wetlands (Kibuku District) for the period 1995-2024

Temperature data were grouped into four groups, representing the decadal periods since the 1990s. A Kruskal-Wallis rank sum test (Kruskal & Wallis, 1952) was performed to test the null hypothesis that there is no significant decadal variation in minimum temperature ($H0_T$-1) and maximum temperature around Limoto wetlands ($H0_T$-2). Temperature was set as the dependent variable, while decadal period was set as the independent (categorical) variable with four levels (that is, 1990s, 2000s, 2010s, and 2020s). Because the test was significant, pairwise comparisons were performed using the Wilcoxon rank sum test (Mann & Whitney, 1947), with continuity correction and p-values adjusted using the BH method (Benjamini & Hochberg, 1995).

For rainfall, the monthly total rainfall was summed for each year. A Mann–Kendall test (Mann, 1945; Kendall, 1975) was performed to test the null hypothesis that there was no significant trend in annual rainfall over 30 years ($H0_R$-1). Afterwards, a standardized precipitation index (SPI), which provides a corrected measure of rainfall abundance and deficit, was used to characterize the extreme years (that is, wet and dry years). The SPI was calculated as the standardized difference between total annual rainfall and the long-term average (Tumbo, 2007). The long-term average was set to represent the period 1995-2024, corresponding to the last three decades used in comparing climate anomalies.

Using rainfall data, it was also important to explore any changes in the scheduling of the periods due to climate variability. Based on the classification of seasons by Komutunga and Musiitwa (2001) above, the months of March and September were chosen to represent the onset of long and short wet seasons, respectively. A Mann–Kendall test (Mann, 1945; Kendall, 1975) was performed separately on March and September data to test the null hypothesis that there was no significant trend in March ($H0_R$-2) and September ($H0_R$-3) rainfall over 30 years, implying no shift in the onset of the rainy seasons.

These hypotheses imply that farmers could choose any of the seasons. However, the total rainfall received during the entire season could be different. Consequently, another hypothesis ($H0_R$-4), testing the similarity of rainfall during the short-rainy season (September-November) and the long-wet season (March-April), was tested using the Wilcoxon rank sum test with continuity correction. Hypothesis $H0_R$-4, whether accepted or rejected, does not tell whether the amount of rainfall received over these seasons has remained the same over the years. Consequently, additional trend analyses were performed on rainfall totals for all the months that make up the long-wet season and short-wet season. The analyses included one where the hypothesis was a non-significant trend in the long-rainy season ($H0_R$-5) and another where the hypothesis was a non-significant trend in the short-rainy season ($H0_R$-6).

For the questionnaire-generated data on the farmers' perceptions of extreme climate events, including the frequency of dry and wet events, change in timing of the seasons, and extreme dry and wet years, which were collected to augment the quantitative weather data, descriptive statistics were used. Specifically, relative proportions were computed for qualitative responses regarding extended or shortened drought periods, extended or shortened rainfall periods, increased or decreased flooding episodes, and changes in the timing of the season. The responses to extreme drought or rainy years were summarized using the median and compared with the SPI computed from the weather data above.

3.5.2 Farmers' perceived impacts of climate variability on rice production and the factors that shape these perceptions

The farmers' perception on the trend in rice yield per unit area, impact of climate variability on rice quality, farming area, harvesting cycle, income, and markets was analyzed using descriptive statistics. Relative proportions were calculated for the perceived impact due to either flooding or drought.

The above descriptive statistics were augmented with two statistical tests. The first one tested the null hypothesis that there was no significant difference in rice yield per unit area between the wet and dry seasons ($H0_Y$-1). A Wilcoxon signed-rank test (Mann & Whitney, 1947) was used for this analysis. The second tested the null hypothesis that there is no significant decadal variation in rice production ($H0_Y$-2). Because there was no continuous time series data on rice yield per unit area, a quasi-temporal dataset created above on basis of the "wisdom of crowds" phenomenon, representing yield in different periods, was used to perform a Kruskal-Wallis rank sum test (Kruskal & Wallis, 1952), where the dependent variable was the log-transformed yield per acre (to normalize the guesses), while independent (categorical) variable was decadal period (as used in climate analysis above). Pairwise comparisons were performed using the Wilcoxon rank sum test, with continuity correction and p-values adjusted using the BH method (Benjamini & Hochberg, 1995).

3.5.3 Factors influencing effectiveness of adaptation to climate variability on rice production

Twelve adaptation strategies were examined during the survey, including early planting, use of early-maturing rice varieties, drought-resistant varieties, shifting to waterlogged areas, reducing the size of the garden, use of fertilizers, farrowing, value-addition, exiting the farming, diversifying into other enterprises, water channeling, and increasing acreage/area of land under farming. Because these responses were categorical, their importance was analyzed by computing relative proportions.

Of the 12 identified adaptation strategies, only three, i.e., value-addition, exiting the farming, and diversifying into other enterprises, were common to both climate extremes (i.e., floods and drought). The rest were either mentioned for floods or drought, but not both. Out of the three, diversification was the only strategy reported by more than 80% of the respondents in both climate extremes (drought and floods). Others ranged between 17 and 35% of the respondents. Accordingly, the drivers of adaptation were explored only for the diversification strategy. The level of diversification was presumed to be influenced by demographic factors. These demographic characteristics were first summarized using descriptive statistics.

For categorical variables (for example, gender, education level, marital status, residence status, social grouping, and technology use), relative proportions were calculated. For the quantitative variables (for example, age, years of farming experience, household size, and income), median values were computed. Median values were preferred to mean values to mitigate the effect of any outliers, which are challenging to eliminate objectively in cross-sectional studies. Afterwards, the consequence of the demographic structures on the level of adaptation was explored using a logistic regression model.

Initial data exploration revealed that farmers diversified their activities by engaging in various enterprises, including trade (wholesale/retail), other non-rice crops, livestock farming, Fishing, Fish farming, crafts, roofing materials, brick laying, sand mining, charcoal burning, and hunting. Others did not engage in any enterprise apart from rice farming. These responses were coded to create a binary response variable, with one representing farmers who were engaged in more than one non-crop enterprise (i.e., “highly diversified”) and zero otherwise (i.e., “less diversified”). A logistic regression model was built toward test the null hypothesis that demographic characteristics of the rice farmers (predictor variables) have no significant influence on diversification to non-crop livelihood activities (binary dependent variable) ($H0_D$-1). The model was built using the ‘glm’ function in R software, where the family was set to ‘binomial’ and the link function set to ‘logit’.

The quantitative predictors (for example, age, years of farming experience, household size, and income) were standardized using the scale function in R software to compare their effects on a common scale. Only model coefficients, the odds ratios, and p-values are included in the results section. The coefficients represent the change in log-odds of diversification for a one-unit change in the predictor, holding others constant. For the categorical variables, coefficients are relative to the reference level, that is, male (gender), none (education level), single (marital status), temporary (residence status), ‘yes’ (use of technology), and ‘yes’ (belonging to a social group). Finally, the function ‘vi’ in the ‘vip’ package of R software was used to rank the influence of the predictors on diversification and generate the variable importance plot for easy visualization. The overall model fit was assessed using the Hosmer-Lemeshow test, whose goodness-of-fit statistic ($\chi^2_{(8)} = 11.7$) and a non-significant p-value ($p = 0.1611$) suggested that the model fitted the data well.

3.6 Ethical considerations

Throughout the study, data collectors adhered to the principles of informed consent, confidentiality, privacy, respect, non-exploitation, transparency, harm minimization, and ethical approval. Before any interview or focus group discussion, the data collectors explained to the participants the aim of the study, its objectives, how the information would be used. Because of low literacy levels, verbal consent was considered adequate. Nonetheless, respondents had the prerogative no to be interviewed that particular moment. Unnecessary personal information, such as telephone contacts, was avoided. Interviews and focus group discussions were conducted mainly at the participants' places of work, which was convenient for them. Cultural norms, practices, and languages were respected at all times. All data collectors used applicable local languages. All participants were shown equal respect regardless of their economic and social status.

3.7 Environmental and gender equality integration

A gender-sensitive approach was used throughout the research process. The data collection tools were designed to capture gender-specific disaggregated data. Equal participation of men and women could not be achieved because of the dominance of men in rice farming. Nonetheless, where both male and female members were available for a household, opportunity was given to the women, unless they declined the interview.

3.8 Limitation to the Study

During the course of the research a number of constraints encountered included:

Financial constraints. This was based on the point that the cost of research materials was expensive. To solve this problem, the researcher solicited for funds from friends and relatives, and family members.

Some respondents never wanted to give information freely about wetlands in relationship to wetland rice production because of fear that government would evict them from wetlands. To prevent this, the researcher explained to the respondents that the responses given by them were to be treated with confidentiality and was to be used for academic purposes only.

Accessing the respondents in their households was not easy for the researcher since most of the respondents had other commitments outside their locality. The researcher had to make appointments with the respondents before conducting the research exercise.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

The chapter contains information about the study, which the researcher collected from the field by use of questionnaires and interview guide.

4.2 The trends and challenges of climate variability in Limoto wetlands from 1995-2024

Data on temperature around Limoto wetlands revealed a slow rise in the monthly minimum temperatures over the past four decades (Figure 2). The difference in median (of the 'minimum') temperature between decadal periods was significant ($H_{(3)} = 38.9$, $p<0.05$, $n=480$), with a moderate effect size ($\varepsilon^2 = 0.075$). Pairwise comparisons further confirmed that each successive decade experienced statistically significant increases in minimum temperatures relative to the 1990s ($p < 0.05$, Figure 2), except between the 2010s and 2020s, where no statistically significant difference was detected in the data ($p > 0.05$). These statistics suggest strong evidence to reject the null hypothesis regarding minimum temperature ($H0_T$-1), implying there has been a significant decadal increase in decadal minimum temperatures around the Limoto Wetlands.

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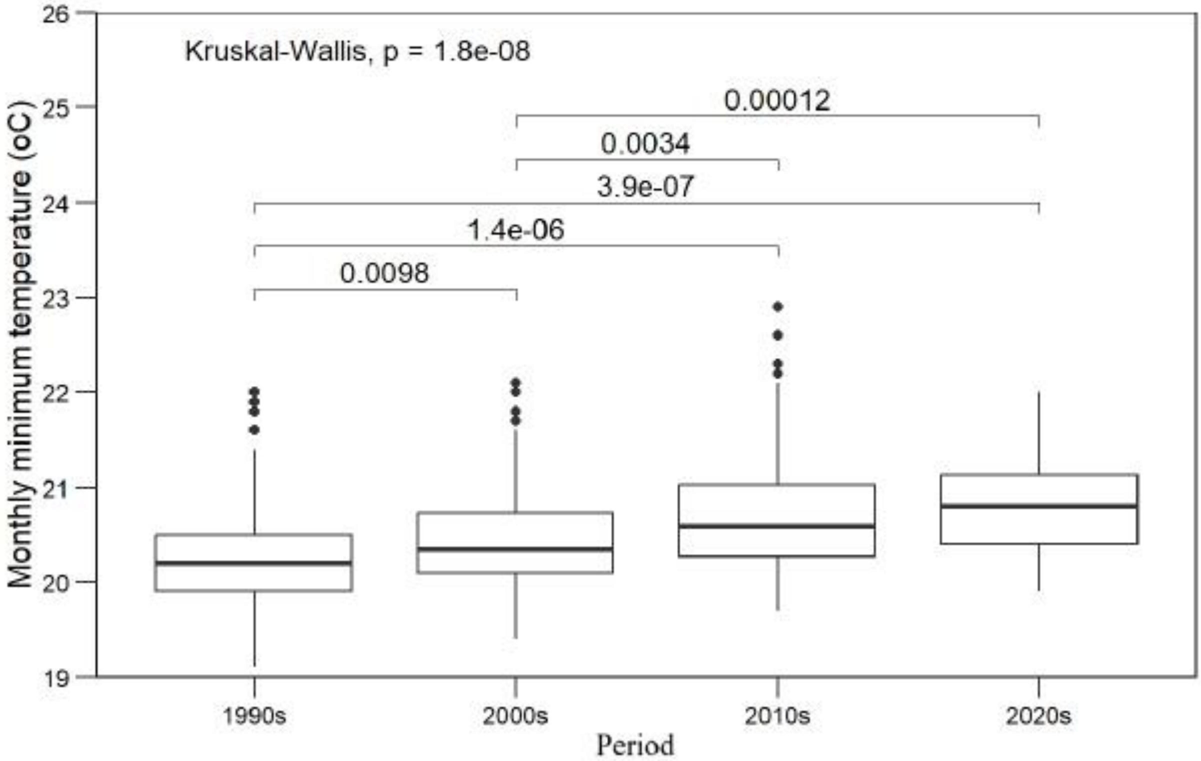

Source: Secondary Data

Figure 2: Decadal analysis of minimum monthly temperature for the period 1994-2024.

Values show p-values from multiple comparisons using the Wilcoxon rank sum test. Non-significant p-values from the comparisons of the 2010s and 2020s omitted.

The results from the analysis of minimum temperature in Figure 2 above were consistent with those of maximum temperature, where the decadal increase in maximum temperature was significant between the 1990s and 2010s (Figure 3). The medians within each boxplot indicate a slight upward shift over time, particularly from the 1990s to the 2010s. However, the 2020s appear to show a stabilization or slight reduction in median maximum temperatures. However, the magnitude of the decadal difference was smaller for maximum temperature ($H_{(3)} = 9.67$, $p = 0.02$, $n=480$), with a small effect size ($\varepsilon^2 = 0.014$), compared to that of the minimum temperature. The most notable difference, as highlighted by the pairwise p-value (0.0026), was observed between the 1990s and 2010s, suggesting a marked increase in monthly maximum temperatures during that period. These statistics also suggest strong evidence to reject the null hypothesis regarding maximum temperature ($H0_T$-2), implying there has been a significant decadal increase in decadal minimum temperatures around the Limoto Wetlands.

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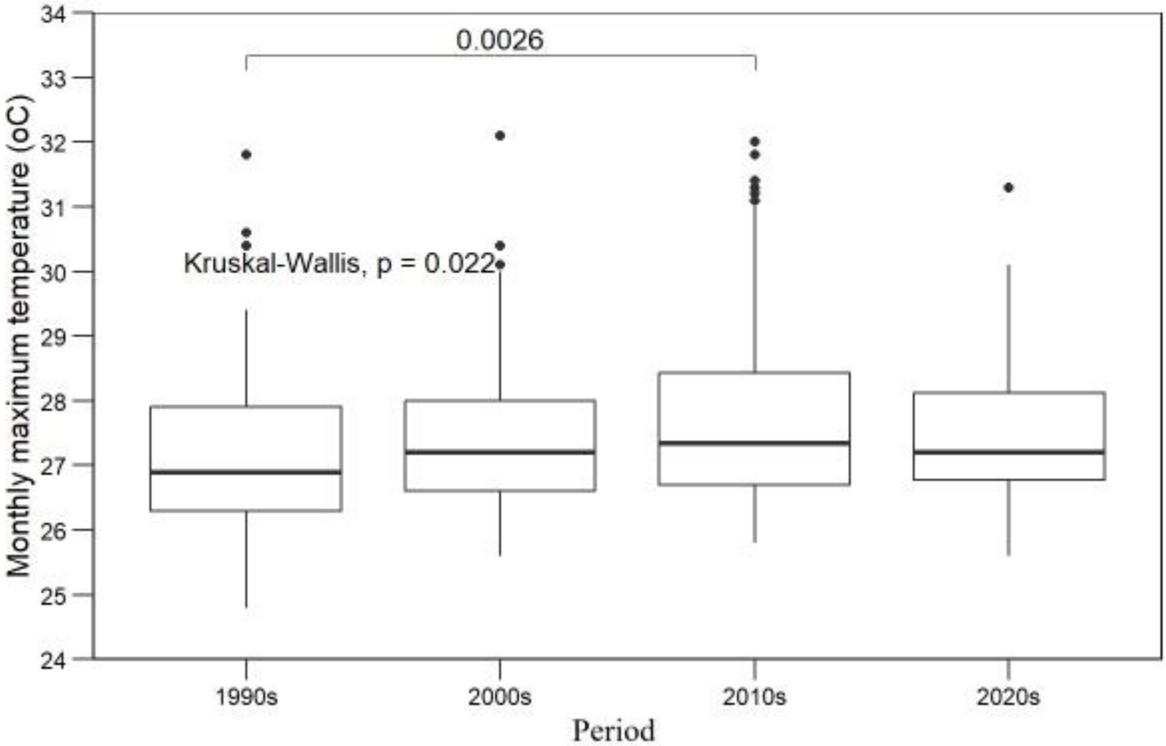

Source: Secondary Data

Figure 3: Maximum monthly temperature around Limoto wetlands from 1995-2024

Values show p-values from multiple comparisons using the Wilcoxon rank sum test. Non-significant p-values from multiple comparisons are omitted.

Rainfall increased from around 2000 to 2008, declined consistently for the subsequent five years, but has been increasing for the last 10 years. These statistics suggest there is strong evidence to accept the null hypothesis (H0R-1), implying that annual rainfall, over a long-term period, has remained the same, despite substantial inter-annual variability. The findings from the research reveal notable indication that climate variability in Limoto Wetlands, as indicated by shifts in temperature and rainfall patterns. Farmers reported increasingly unpredictable rainfall seasons, characterized by premature cessation (although this was not evident in weather data), and erratic distribution. This aligns with prior studies such as Nabikolo et al. (2019), which noted that smallholder farmers across Uganda have been experiencing similar rainfall anomalies, resulting in compromised planting schedules and crop production. Additionally, quantitative analysis of meteorological data showed statistically significant deviations from historical averages, supporting the assertion of a changing local climate regime.

Temperature variability was also perceived by the majority of respondents, who reported higher daytime temperatures and warmer nights than in previous decades. These observations are consistent with reports from the Uganda National Meteorological Authority (UNMA), which has documented a gradual rise in average annual temperatures across the eastern region (UNMA, 2020). The implications of elevated temperatures are far-reaching, including increased evapotranspiration, shortened crop growth cycles, and heat stress on rice plants, factors that negatively influence yield quality and quantity.

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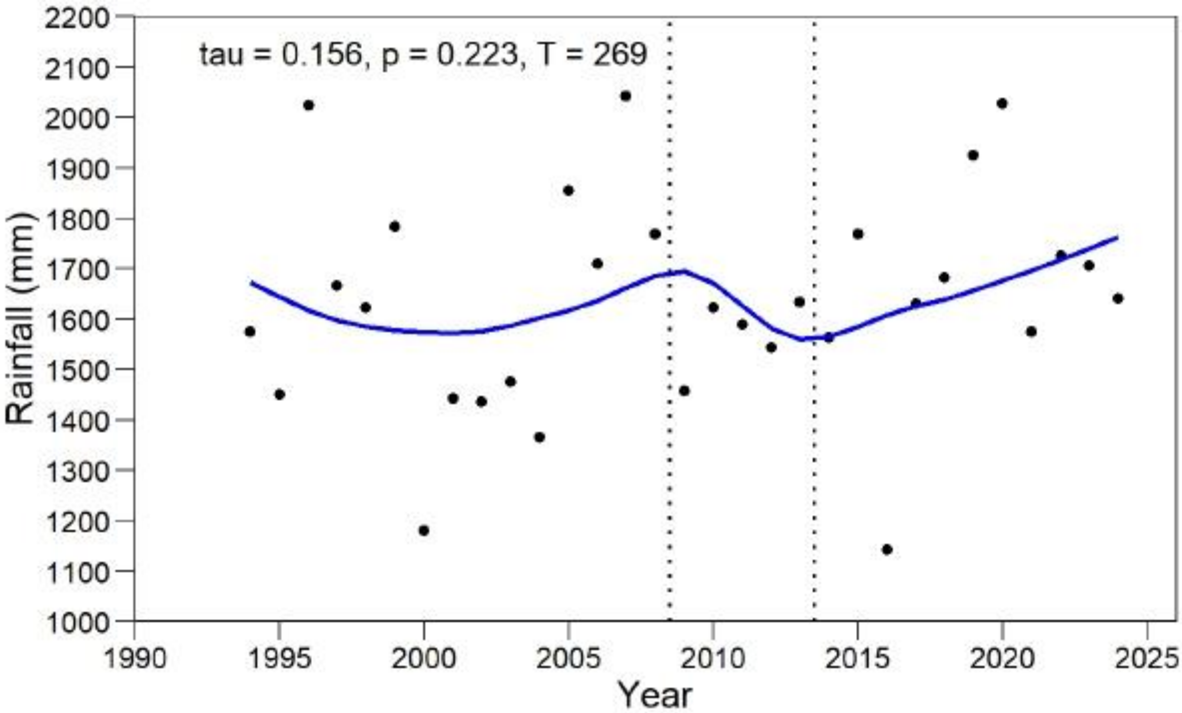

Source: Secondary Data

Figure 4: Annual rainfall around Limoto wetlands for the period of 1995-2024

The blue line shows the trend line fitted using the Kendal method (Kendall, 1975). The vertical dotted lines show the years when there was a change in the direction of the trend.

The inter-annual variability in rainfall was explored in more detail using the standardized precipitation index, leading to a classification of years into extreme dry and wet years (Figure 4). Generally, the early and late 2000s, throughout most of the 2010s, were characterized by dry years: from 1999 to 2004, the region experienced a series of negative anomalies, suggesting a prolonged dry spell, similar to the period 2008-2017. Extreme anomalies were observed in 2000 and 2016, both recording SPI values below -2, signifying severe drought.

Interestingly, farmers' responses to the driest years were consistent with the analysis of the rainfall anomalies in Figure 5. For example, 2011 and 2017 were the most mentioned years with drought conditions, with 44 and 37 mentions respectively. Conversely, 1996, 2007, and 2019 recorded SPI values above +1.5, indicating significantly wetter conditions. The period from 2018 showed a shift toward wetter conditions, especially in 2018 and 2019. These were also consistent farmers' responses on the wettest years, with the years 2014 and 2018 mentioned 40 and 37 times, respectively.

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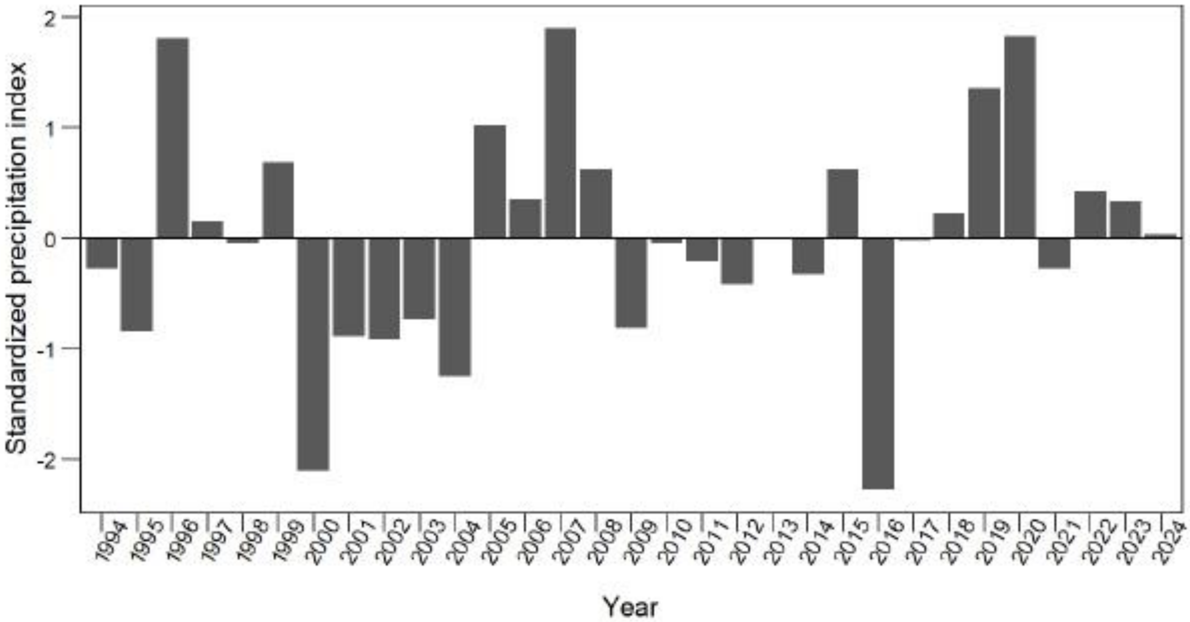

Source: Secondary Data

Figure 5: Annual rainfall anomalies around Limoto wetlands for the period 1995–2024.
Positive Standardized Precipitation Index (SPI) values (bars above the zero line) indicate wetter-than-average years, while negative values (bars below the line) represent drier-than-average conditions. The height of each bar (regardless of the sign) indicated the magnitude of the deviation in yearly precipitation from the long-term average.

Total yearly rainfall may affect agricultural production, but at the farm level, the onset of rainy seasons and the total amount of rainfall received throughout the entire wet season have a greater impact on the farmers as they directly influence the timing of planting seasons. The latter was addressed by two hypotheses, where a significant trend in March rainfall ($H0_R$-2) and September rainfall ($H0_R$-3) over 30 years was not expected, implying no shifts in planting dates (section 3.8.1). Figure 8 shows that there is a consistent and significant increase in September rainfall (Kendall tau statistic, $\tau = 0.286$, $p < 0.05$), which is inconsistent with hypothesis H0R-3, while the trend for March rainfall is non-significant (Kendall tau statistic, $\tau = 0.062$, $p > 0.05$), which is consistent with hypothesis H0R-2. None of the trends suggested decreasing rainfall during the first months of the long-wet and short-wet season.

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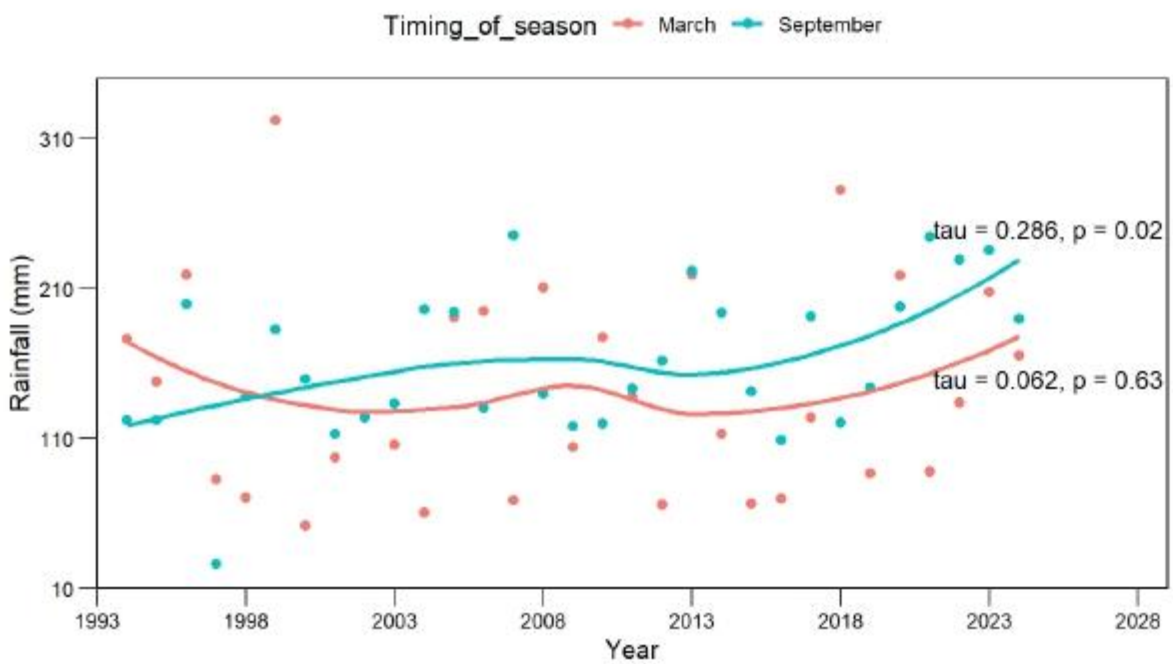

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Figure 6: Trend analysis of rainfall seasons onset of long-wet (March), short-wet (Sept).

Whereas there was no declining trend in the onset of wet season rains, the increasing rainfall for September (short-wet season) could influence the timing and effectiveness of rice farming activities, possibly encouraging farmers to adjust planting calendars. This shift could easily happen if the total rainfall received during the short-wet season matches that received during the long-wet season. Figure 8 shows that the median rainfall received during the long-wet season, as expected, was higher than the short-wet season. However, the difference was not significant ($W = 597$, p-value > 0.05, Figure 9), implying that hypothesis H0R-4 could be accepted.

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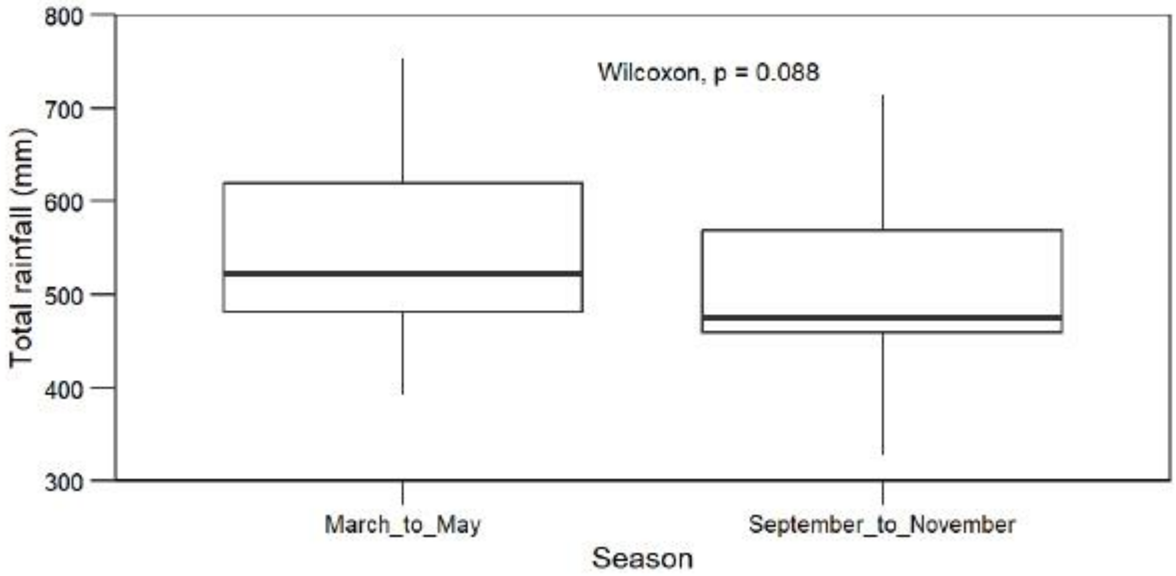

Source: Secondary Data

Figure 7: Rainfall seasons received long-wet (March-May) and short-wet (Sept-Nov).

Figure 7 illustrates the trend analysis of total seasonal rainfall received around the Limoto wetlands during the long-wet season (March to May) and the short-wet season (September to November) from 1995 to 2024. The trend in total rainfall for each season is non-significant, consistent with hypotheses $H0_R$-5 (for the long-rainy season) and $H0_R$-6 (for the short rainy season). However, the long-wet season exhibited a declining trend, starting from around 2008. On the other hand, the short-rainy season exhibited an increasing trend, which became consistent from 2013 onwards. Since 2020, the total amount of rainfall received during the short-rainy season has surpassed that received during the long-wet season.

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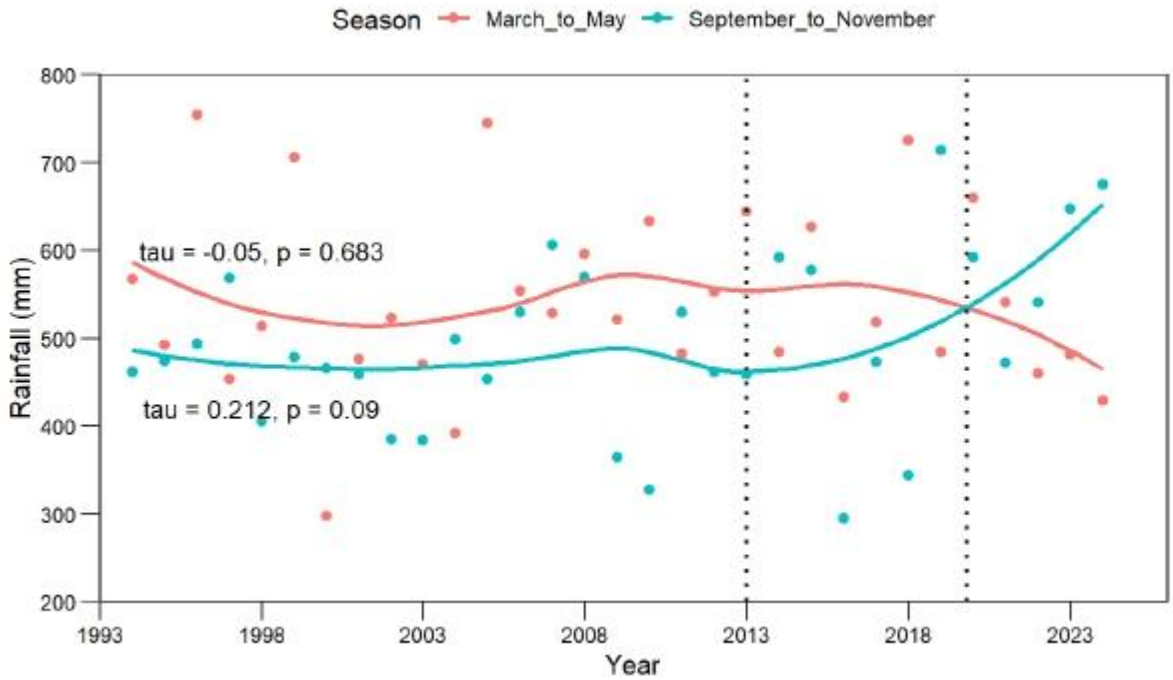


Source: Secondary Data

Figure 8:Trend analysis of total rainfall for long-wet (March-May), short-wet (Sept-Nov).

Each season is fitted with a trend line, Kendall's tau coefficients, and associated p-values, assessing the strength and significance of the observed trends. Importantly, the reliance of rice farmers on traditional knowledge and observations such as changes in planting signals, soil moisture behavior, and seasonal cues further affirms that climate variability is not only a scientific abstraction but a lived experience for local communities. However, the mismatch between farmers' observations and formal weather predictions often limits their capacity to plan effectively, highlighting the need for localized and farmer-accessible climate information services.

The study confirms that both scientific and farmer-reported data point to substantial climate variability, especially regarding rainfall unpredictability and rising temperatures. These climatic shifts present a serious challenge to rice production in wetland ecosystems like Limoto, necessitating tailored adaptation responses and improved forecasting systems to safeguard livelihoods.

4.1 Farmers' perceived impacts of climate variability on rice production and the factors that shape these perceptions

The above data are consistent with the perception of farmers on climate variability. From the interviews, all respondents reported experiencing variability in climate variables, primarily temperature and rainfall, over the last 5-20 years. About 94% of the respondents reported changes in the timing of seasons; 88.1% of the respondents reported extended dry periods, while only 38.4% reported having experienced an increase in wet seasons

According to the interviews, approximately 95% of the respondents revealed decrease in rice Kilograms per unit area over the 30-year period. Of these respondents, 43% revealed a substantial decline, while 57% reported a slight decline in kilograms. About 78.2% of respondents reported that dry season as part of climate variability that led to poor yields; 18.9% reported extended wet season and hailstorms, while 2.7% perceived strong winds as the climate extreme that affected kilograms. Table 1 shows the perceived impact of wet and dry seasons on various aspects of rice farming (i.e., kilograms, quality, farming area, harvesting cycles, income, and markets). Both dry and wet seasons were observed to affect these aspects in comparable magnitude, except markets, where disruptions were twice as high during the wet season as during the dry season, possibly linked to infrastructure damage or post-harvest spoilage during wet season. Also, the impact on rice quality was more strongly associated with extended wet seasons (98.5%) than dry season (64.6%), possibly due to waterlogging and post-harvest losses.

Table 1: Relative proportions (%) on the impacts of wet and dry seasons on rice farming

Impact	Wet season	Dry season
Reduced rice yields	58.6	99.6
Reduced rice quality	98.5	64.5
Increased rice yields	46.3	-
Reduced rice farming areas	80.6	97.8
Disrupted rice harvesting	97.8	98.9
Reduced income	100	91.8
Poor market for rice	69.4	31.3

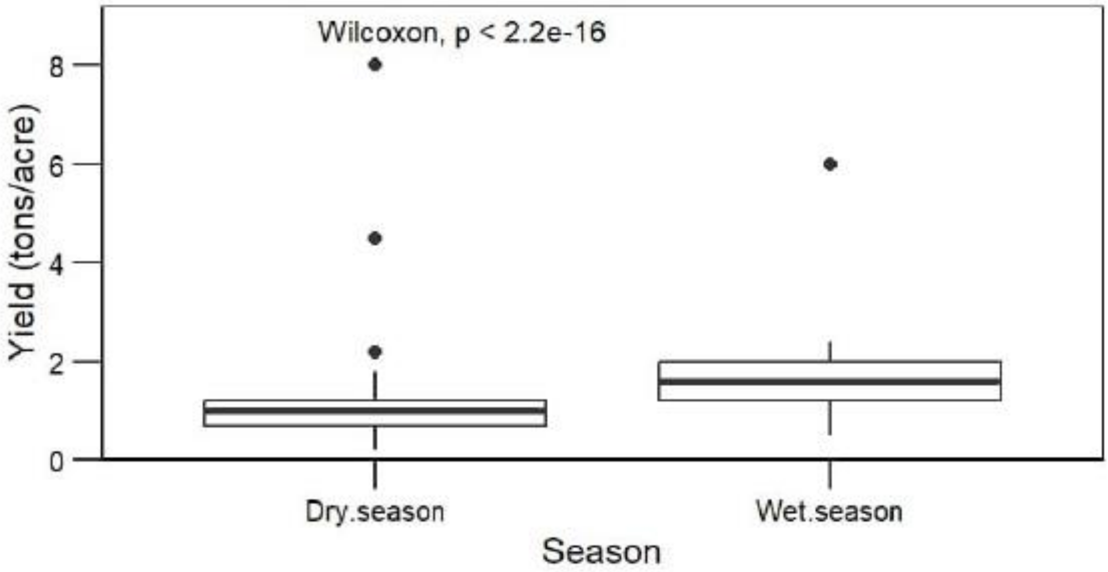
Source: Data from the field

Content analysis of Focus Group Discussions (FGDs) responses showed that the most significant concern was the low quantity and poor quality of rice yields received during dry seasons, which was reported to negatively impact business. Dry conditions were linked to poor quality due to light grains, while excessive drying led to broken grains during milling. On the other hand, some farmers noted that rainy seasons were associated with heavier grains and better yields, but this was not wholly supported by other members. What was unanimously reported was that rainy conditions caused discoloration of rice (turning brownish), excess moisture, and poor drying. Interestingly, three millers reported receiving more rice during the dry season due to the ease of drying, indicating that certain climatic conditions may offer limited advantages. Overall, these findings reveal a strong correlation between climatic events and rice quality, highlighting the need for climate-resilient practices.

Before any statistical interpretations could be made on the farmer's perception of the effects of climate variability on rice production, it was important to test whether rice production was different between wet and dry seasons (H0Y-1). Figure 10 shows the sufficient evidence to reject the hypothesis H0Y-1; that is, rice production (defined as yield per unit area) is significantly higher during the wet season than the dry season. This finding from the hypothesis H0Y-1 test is consistent with the individual interview and Focus Group Discussions (FGDs) data above, especially where 41% more respondents reported low yield per unit area during dry season than wet season (Table 1).

Furthermore, the quantitative data from farmers highlighted that during dry periods, rice yields were not only lower in volume but also of poorer quality, often lightweight, broken, and with less attractive colors. On the other hand, kilograms from wetter seasons were more abundant, though frequently compromised by poor post-harvest handling conditions due to excessive moisture. Such findings support the double-edged nature of climate variability: while rainfall is critical to wetland rice production, its inconsistency undermines production when not well-distributed.

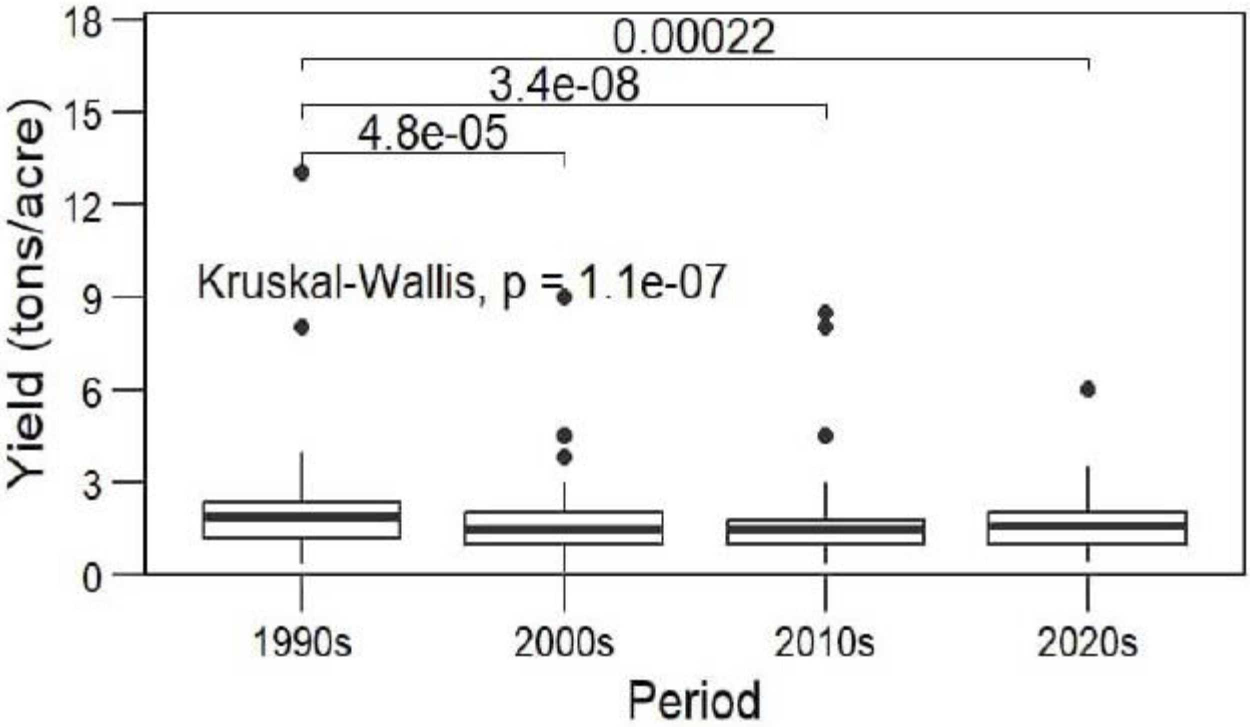
Summarizing, climate variability has multiple impact on rice production in Limoto Wetlands, affecting not only rice yields but also quality and market value. The findings reinforce the essential for climate-smart farming actions, improved irrigation infrastructure, and early warning systems to enable rice farmers to adapt, adopt and sustain rice production amidst environmental uncertainty. Results from individual interviews in Table 1 were consistent with responses from Focus Group Discussions (FGDs) with farmer groups and other actors such as traders and millers.



Source: Data from the field

Figure 9:Comparison of rice production (yield per tons per acre)

From study findings demonstrate a strong perception by the farmers shows the relationships between climate variability and rice production in the Limoto Wetlands of Kibuku District. Respondents consistently indicated that erratic rainfall patterns and prolonged dry spells have adversely affected the quantity and quality of rice yields. The above data are consistent with the perception of farmers on climate variability. From the interviews, all respondents reported experiencing variability in climate variables, primarily temperature and rainfall, over the last 5-20 years. About 94% of the respondents reported changes in the timing of seasons; 88.1% of the respondents reported extended dry periods, while only 38.4% reported having experienced an increase in wet events. These observations are supported by studies such as Stuecker et al. (2018) and Omondi et al. (2020), which similarly document the vulnerability of rain-fed rice systems in sub-Saharan Africa to changing climate patterns.



Source: Data from the field

Figure 10: Decadal changes in rice production (Kilogram/ tons per acre per season).

Values show p-values from multiple comparisons using the Wilcoxon rank sum test. Non-significant p-values from multiple comparisons are omitted.

Figure 10 shows a boxplot analysis of decadal changes in rice production. The Kruskal-Wallis test showed a highly significant difference in rice Kilogram per unit area across decades ($H_{(3)} = 35.2$, $p < 0.05$, n=1072). Multiple comparisons showed a significant decrease in rice production from the 1990s to the 2010s ($p < 0.05$), followed by a slight increase (non-significant) during the 2020s (non-significant p-value not shown in Figure 12). These results are consistent with climate data presented in section 4.1, showing a significant increase in temperature from the 1990s and stabilizing after the 2010s and a consistently higher annual rainfall (above the long-term average) during the 2020s. Hypothesis $H0_Y$-2 is, therefore, rejected.

4.3 Factors influencing effectiveness of adaptation to climate variability on rice production

The adaptation influencing factors for farmers to either dry or wet were diverse. For dry-related adaptations, early-maturing and drought-resistant rice varieties, fertilizer application, expanding into water-logged areas or reducing garden size, and diversifying into other enterprises were the most common reported interventions (Table 2). Under wet conditions, water channeling, increasing acreage under farming and diversifying to other enterprises were the most common adaptation strategies (Table 2).

Table 2: Relative proportions (%) adaptation measures by farmers

Adaptation measures	Dry season	Wet season
Early planting	38.8	
Use of early-maturing rice varieties	98.1	
Drought-resistant varieties	98.9	
Expanding to waterlogged areas	68.7	
Reducing the size of the garden	70.1	
Use of Fertilizers	91.8	
Farrowing	50	
Value-addition	35.1	63
Diversifying into other enterprises	81	88.9
Water channeling		98.5
Increasing acreage/area of land under farming		92.1

Source: Data from the field

Diversification to other enterprises was the only adaptation strategy reported by more than 80% of the farmers for both dry and wet conditions (Table 2). What increases or decreases the odds of rice farmers diversifying? The demographic and socio-economic profiles were essential for understanding the adaptation drivers. For rice farmers from Limoto wetlands, demographic characteristics revealed a moderately educated, socially embedded, and technologically engaged community (Table 3). The median number of years in rice farming was 15, indicating a relatively experienced farming community. Gender distribution showed a slight male majority, but this statistic should be interpreted with caution because male respondents did not mean the women were not involved. Males preferred to speak, especially for married households, which constituted 89.2% of the respondents. Conversely, where female respondents were involved, men did not participate actively in farming (field observations). Therefore, females are more engaged in rice farming, contrary to the indication in Table 3. The median age was 41 years, reflecting a mature farming population.

In terms of education, most respondents who attained primary education, only a small proportion attained tertiary education, implying rice farming is a core livelihood source. Marital status data reveal that most farmers were married, which correlated strongly with larger household sizes, potentially influencing labor availability. The vast majority of farmers were permanent residents, suggesting a strong place-based attachment, which is important for long-term adaptation planning. Social group membership is high, especially in agricultural groups, religious groups, and SACCOs, indicating a strong social capital base that can be leveraged for collective adaptation. In terms of technology use, telephone communication was the most prominent, followed by social media, while radio adverts lag (33.2%).

The study from the field reveals that small rice farmers in Limoto Wetlands accepted a wide range of adaptation measures to cope with the effects of climate variability. Among the most reported strategies are the introduction of quick-maturing and drought-tolerant rice varieties, timely land preparation, and the use of fertilizers and pesticides to enhance resilience against pests and diseases caused by erratic weather patterns. These findings align with the work of Deressa et al. (2009), who emphasized the importance of varied adaptation and input use in climate-vulnerable agricultural systems.

Table 3: Summary of demographic characteristics of rice farmers in Kibuku district

Variable	Metric
Years in rice farming (Median)	15
Gender (%)	
Male	56.8
Female	43.2
Age (Median)	41 Years
Education (%)	
None	6.3
Primary	55.6
Secondary	21.6
Tertiary (Certificate)	13.4
Tertiary (University)	3
Marital status (%)	
Married	89.2
Single	10.8
Residence status (%)	
Permanent	90.9
Temporary	9.1
Social grouping (%)	
Credit group (SACCO)	73.1
Religious group	76.4
Agricultural group	85.4
None	5.6
Bereavement group	0.7
Use of technology (%)	
Social media for marketing	53
Telephone communication	97.3
Radio adverts	33.2

Source: Data from the field

At a glance, gender was the most influential driver of diversification, followed by, in the order of importance, years of experience, education level, residence status, age, marital status, household size, farm size, social belonging, farm kilograms per acre, and income per season

(Figure 10). Whereas Figure 10 shows the relative importance of each variable on diversification, it does not reveal the magnitude of the variable's influence on diversification and whether that magnitude is statistically significant ($H0_D$-1). The output from a logistic regression model showed that demographic and socio-economic variables significantly influence the likelihood of farmers to diversify, contrary to hypothesis $H0_D$-1 (Table 4).

Statistically significant variables ($p < 0.05$) included gender, years in rice farming, education levels, residence status, age, and marital status. For instance, farmers with primary level education were about 11 times more likely to diversify than those with no education, with the likelihood increasing to 19 times for farmers with secondary education (Table 4). Although not all were significant, years of experience, household size, farm yield, and income per season had negative coefficients, implying that a component rise in these variables is related with reduced odds of diversification (Table 4).

Social and institutional interventions also featured prominently. For instance, the provision of agricultural loans and access to extension services were mentioned as key enablers of adaptation. Through sensitization meetings and training, farmers have gained knowledge about agronomic practices such as proper spacing, soil fertility management, and post-harvest handling. These practices are not only critical for climate resilience but also for improving production and reducing losses.

However, while many farmers have adopted some form of adaptation, the scale and efficiency of these approaches are frequently affected to get low financial loan resources, suitable weather information, and appropriate technologies. This highlights a gap between awareness and capacity, suggesting the need for stronger institutional support, targeted subsidies, and inclusive adaptation planning.

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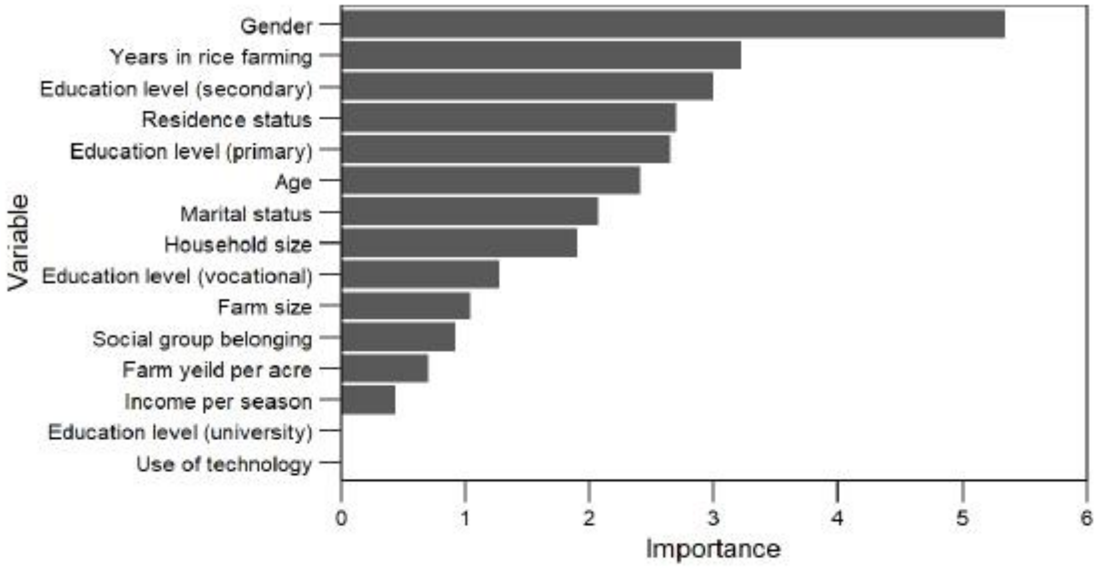

Source: Data from the field

Figure 11: Ranking of demographic features of farmers as by their influence on adaptation.

Gender also emerged as an influential factor, with male farmers generally having better access to extension services, credit facilities, and land ownership compared to their female counterparts. This disparity reflects broader structural inequalities that hinder women's adaptive capacity, despite their active participation in rice farming. Addressing gender barriers through inclusive extension services and targeted support is thus essential for building community-wide resilience.

Study findings underscore that socio-economic characteristics takes a crucial part in enhancing farmers' capability to adapt to climate variability in the Limoto Wetlands. Factors including education level, income status, land tenure system, gender, and membership in farmer organizations significantly influence how farmers perceive climate dangers and the level to which they implement adaptive practices, such as diversification. Educated farmers were seen to accept modern adaptation actions such as improved rice varieties and irrigation technologies. This is consistent with findings from Nhemachena and Hassan (2007), who reported that education enhances the ability of farmers to access and interpret climate information, thereby improving decision-making. Similarly, farmers with higher incomes and larger land holdings, while they were less diversified, demonstrated a greater capacity to invest in technologies and inputs that improve resilience, such as mechanization and water storage systems.

Moreover, membership in farmer groups or cooperatives were found to facilitate access to climate-related training, input subsidies, and collective marketing arrangements. These networks not only reduce individual risk but also enable knowledge sharing and innovation diffusion. Farmers who belonged to such groups were more confident and proactive in implementing adaptive practices compared to isolated farmers. The dependent variable is the level of diversification and the independent variables represent socio demographic factors.

Table 4: Summary of results of the logistic regression model.

Independent variable	Coefficient	p-value	Odds ratio
Years in rice farming	-0.98	0.0012	0.375
Gender	2.29	9.26E-08	9.934
Age	0.79	0.0161	2.221
Education level (secondary)	2.96	0.0027	19.46
Marital status	1.67	0.0384	5.316
Residence status	-1.87	0.0069	0.153
Education level (primary)	2.44	0.0079	11.55
Household size	-0.41	0.0580	0.659
Education level (vocational)	1.26	0.2026	3.540
Farm kilogram per acre	-0.13	0.4814	0.878
Farm size	0.31	0.2985	1.356
Social group belonging	0.65	0.3540	1.929
Income per season	-0.22	0.6621	0.802
Education level (university)	18.01	0.9894	6.6E-07
Use of technology	-16.26	0.9967	8.63E-08

Source: Data from the field

What constrains adaptation among the rice farmers in Limoto wetlands? This question was answered with a combination of surveys, Focus Group Discussions (FGDs), and Key informant interviews (KIIs). From the questionnaire, farmers listed financial constraints/limited credit facilities, shortage of material on climate change, inadequate government support, and limited land for diversification/land tenure system, limited rice varieties, unaffordable irrigation facilities, and high dependence on rice as the significant constraints to adaptation. Except for the high dependence rice, all other constraints were mentioned by more than 90% of the farmers. High dependence on rice was mentioned by 41% of the farmers.

The farmers' considerable knowledge of constraints of adaptation and the possible interventions to reduce them is remarkable. The constraints that were reported are mainly associated with socioeconomic issues income levels, access to resources, education, and social networks ((Nabikolo et al., 2019). Therefore, providing these services can address the constraints. However, the interventions that the rice farmers reported such as improved awareness and membership of social groups that build up resilience against extreme weather events (Adger et al. 2009), should be also considered by development agencies. As an example, increasing awareness has enabled rice farmers to recognize the necessity of adapting, acquire knowledge about available options, have the capacity to assess them and implement the most suitable ones (Musinguzi et al.2015).

Key informant interviews revealed a wide range of involvements being employed to improve rice farming resilience in the Limoto Wetlands amidst climate variability. The most frequently cited were, in order of number of mentions, the introduction of small-scale irrigation systems (emphasizing the critical need for water access due to erratic rainfall), quick-maturing and high-yielding rice varieties (to help farmers to cope with shorter seasons and improve kilograms), fertilizer use, post-harvest handling sensitization, integration of fish farming with rice, provision of agricultural loans, and use of pest-resistant varieties, and wetland restoration.

The analysis of benefits derived from enabling interventions reveals several positive outcomes experienced by rice farmers in the Limoto Wetlands. Improved crop Kilograms and enhanced rice production due to available extension services were the most frequently cited benefits, indicating that production gains, especially during the 2020s (section 4.2), in addition to consistent rainfall, could be attributed to technical and advisory support. Diversification of farming practices was also reported to have contributed to household income, except that this was inconsistent with the results from logistic regression modelling, where an increase in income was associated with reduced odds of diversifying.

Results of the logistic regression model (Table 4) showed that farming experience, technology, social groups belonging and wet season farming days increase the likelihood of diversification to non-farming activities, in line with what has been demonstrated in other studies where by more experience in agricultural activities was found to increase probability of uptake of adaptation strategies (Nhemachena and Hassan 2007). Increased use of technology like mobile phones and radios enhanced access to information needed for adaptation

Notably, the most common intervention cited by farmers was the introduction of small-scale irrigation systems to supplement rainfall and ensure water availability during dry spells. This is a critical adaptation measure given that most rice farming in the area is rain-fed. Farmers also indicated increasing interest in integrating fish farming with rice cultivation, a technique that improves production and income diversification. Such integrated systems have been promoted elsewhere in Africa and Asia as part of climate-smart agriculture (Wassmann et al., 2009).

Access to weather information, especially weather forecasts, has a direct link with the adaptive capacity of farmers. How do farmers of the Limoto wetlands access weather information? Table 2 above shows a population that uses technology, especially phones, social media and radios. Content analysis of key informant interviews (KIIs) data also showed that most rice farmers in the Limoto Wetlands rely heavily on media weather forecasts. This highlights the importance of accessible broadcast channels such as radio and television in climate communication. The meteorology department in the Ministry of Water and Environment (MWE) was also a major source, suggesting that formal meteorological services are increasingly reaching rural farming communities. However, other farmers depend on traditional and experiential sources, such as farmers' experience and community indigenous knowledge, reflecting the continued relevance of local knowledge systems.

Overall, the adaptation strategies in use reflect a combination of indigenous knowledge and modern techniques, influenced by both environmental necessity and external support. The efforts of farmers to effectively react to climatic changes depends not only on their knowledge and resources but also on wider socio-economic and institutional contexts.

Climate adaptation in rice farming communities. Enhancing adaptation requires targeted policies that address structural vulnerabilities and promote equitable access to education, credit, information, and social capital.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The findings of this research inform the following conclusions;

First, on the historical significant changes in seasonal, annual, or decadal temperature and rainfall around the Limoto Wetlands during the past 30 years, the study concludes that significant climatic shifts have occurred. The empirical data demonstrated considerable variability in both precipitation and temperature patterns, including the frequency of dry spells and elevated mean temperatures.

Second, regarding the farmer's perceptions and link between climate variability and seasonal or decadal changes and the rice production in the Limoto Wetlands, it can be resolved that climate variability has a substantial impact on rice production in wetlands. The results indicated an evident decline in rice yields over the last three decades. Farmers consistently reported decreasing production, which was supported by both quantitative rice yield records and qualitative accounts from community rice service providers and Government officers affiliated with the agricultural sector. The decline in rice production was closely associated with erratic rainfall patterns and periodic flooding or drought.

Third, regarding farmer adaptation to climate variability, it can be concluded that demographic characteristics significantly influence livelihood diversification, and hence adaptive capacity. The study indicated gender aspects including such as age, education level, and marital status a critical part in determining the ability of farmers to diversify income sources and implement adaptive strategies. The youths and more educated farmers explore alternative livelihoods such as trading, livestock rearing, or adopting drought-tolerant varieties.

5.2 Recommendation

There are should be possible ways to enhance adaptation, improve means of support, and make sure food is enough in people's homes amidst an increasingly uncertain climatic future through targeted interventions, informed policies, and community-driven solutions.

There should be strengthening targeted interventions to address the challenges faced by rice farmers through empowering them by sensitization, training and Extension Services can enhance adaptation.

Specific and refresher training programs should be scaled up to equip farmers with knowledge on adaptation practices, sustainable land use, and diversification strategies. Emphasis should be placed on reaching susceptible individuals including women, youths and older farmers.

There are should be policies that encourage livelihood options income-generating activities for example, poultry rearing, vegetable growing, and agro-processing should be developed to enhance well-diversified farmers who are ready to adopt to adapt climate variability than those who depend on a single livelihood source.

There should clear avenues to have access to low-interest financing from micro finance banks, revolving SACCOs such as parish development model, and skills training could be vital in enabling these shifts.

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APPENDIX 1: QUESTIONNAIRE FOR RICE FARMER HOUSEHOLD HEADS

I **JOSEPH KAUGULE** a student at Busitema University, pursuing a Master of science Degree in Climate Change and Disaster Management, carrying out research on the **Farmers' perception of the effect of climate variability on rice production and adaptation strategies in Limoto wetlands, Kibuku district**. I take this honour to request you to provide information to me and your responses will be treated as confidential and used for academic purposes only.

Are you willing to take part in this survey and give your consent to the processing of the data?

☐ Yes/continue with the questions

☐ No/Thank the respondent and move to the next respondent

Section A: Demographic Information

- Respondent name ………………………………………………………………………
- Interviewer: …………………………………………………………………………
- Date of interview: ……………………………………………………………………
- Interview number:……………………………………………………………………

Gender:

Male ☐ Female ☐

What is your Age?

<15 ☐ 15-30 ☐ 31-40 ☐ ☐ 41-50 ☐ 51-60 ☐ >60 ☐

What is Marital status?

Married ☐ Single ☐

How many people are in your household?...

What is your highest level of education?

☐ Primary

☐ Secondary

☐ Tertiary—certificate/vocational

☐ Tertiary—University

None ☐

What is your residence status?

☐ Permanent

☐ Temporary (including renting)

How long have you been doing Rice farming in Limoto wetland (open ended question?)

…………………………………………………………………………………………………

What is the appropriate size of your rice garden/ farm in acres?..

…………………………………………………………………………………………………

What is your appropriate income per season?...

…………………………………………………………………………………………………

Section B: Farmers' perceived impacts of climate variability on rice production

Have you noticed changes in Rainfall or Temperature over the past 30 years?

0= No ☐ 1= Yes ☐

What changes in climate have you noticed in the last 30 years?

☐ Extended dry periods

☐ Shortened dry periods

☐ Extended rainfall periods

☐ Shortened rainfall periods

☐ More rainfall

☐ Less rainfall

☐ Change in timing of the season

Which years in the last 30 years, do you remember as extreme dry (s) years?

....

Which years in the last 30 years, do you remember as extreme wet (s) years?

....

Section C: Temporal changes in climate variables on Rice Production

What is your current yield (kg) from one acre of rice?...

…………………………………………………………………………………………

Has yield from one acre of rice reduced during the last 30 years?

0 = No ☐ 1 = Yes ☐

What was the yield from one acre (kg) during these years?

☐ 5 years ago

☐ 10 years ago

☐ 20 years ago

☐ 30 years ago

Which climate change variables have greatly affected your farming business? (Select all that apply)

☐ Wet

☐ Dry

☐ Strong winds

☐ Hailstorms

☐ None

How have these climate change variables impacted your rice farming?

☐ Significantly reduced productivity

- [ ] Slightly reduced productivity
- [ ] No impact
- [ ] Increased productivity

How does extended rainfall/wet season affect your farming in Limoto Wetlands? (Select all that apply)

- [ ] Reduced Rice kilograms,
- [ ] Reduced Rice quality
- [ ] Increased rice kilograms
- [ ] Reduced Rice farming areas
- [ ] Disrupted Rice harvesting
- [ ] Reduced Income from rice farming
- [ ] Increased income
- [ ] Poor market for Rice
- [ ] Other (specify)……………..

How does extended dry affect your rice farming in Limoto Wetlands? (Select all that apply)

- [ ] Reduced rice kilograms,
- [ ] Reduced rice quality
- [ ] Reduced rice farming areas
- [ ] Reduced Income from rice farming
- [ ] Poor market for the rice
- [ ] Other (specify)

What is the average rice Kilograms from one acre during the wet season

……………………………………………………………………………………………………
…………………………

What is the average rice Kilograms from one acre during the dry season

……………………………………………………………………………………………………
……………………………

Section D: Factors influencing adaptation to climate variability by the wetland rice farmers

What factors have influenced the implementation of adaptation to climate variability in in Limoto Wetlands? (Select all that apply)

☐ Early planting of rice
☐ Use of early-maturing rice varieties
☐ Drought resistant varieties
☐ Use of irrigation practices
☐ Extending to new water-logged areas
☐ Reducing the size of the garden
☐ Use of Fertilizers
☐ Fallowing of Land
☐ Rice processing and value addition
☐ Exiting rice farming
☐ Diversifying to other enterprises

What adaptation measures have you implemented in response to extended rainfall/ flooding in Limoto Wetlands? (Select all that apply)

☐ Increasing acreage/ areas of land under farming

☐ Rice processing and value addition

☐ Diversifying to other enterprises

☐ Channeling of water

What other enterprises do you engage in apart from rice farming?

- [ ] Trade (wholesale/retail)
- [ ] Livestock farming
- [ ] Other crops
- [ ] Informal jobs/employment
- [ ] Crafts and roofing materials
- [ ] Brick laying
- [ ] Sand mining
- [ ] Charcoal
- [ ] Fishing
- [ ] Fish farming

What ids the most common Crop grown apart from rice?……………………………………

…………………………………………………………………………………………………

What ids the most common Livestock reared ……………………………………..…………..

…………………………………………………………………………………………………

Have you used any forms of Technology as adaptation strategies to improve rice production amidst climate variability in Limoto wetlands?

0 = No ☐ 1 = Yes ☐

What technology have you used in your farming business?

- [ ] Social media for marketing,
- [ ] Disease diagnosis apps
- [ ] Telephone communication
- [ ] Radio adverts
- [ ] Others (specify)…………………………………………………………………

Which of the following social groups are you a member?

- [ ] Credit group (SACCO)
- [ ] Religious group
- [ ] Agricultural group
- [ ] None
- [ ] Other groups (specify)

What are the interventions farmers perceive to enhance adaptation for rice production in Limoto wetlands? (Open ended question)…………………………………………….......

……………………………………………………………………………………………………

What are the biggest constraints affecting the application of successful adaptation strategies in rice production? (Select all that apply)

- [ ] Financial constraints/limited credit facilities
- [ ] Shortage of information on climate change
- [ ] Inadequate government support
- [ ] Limited land for diversification/ Land tenure system
- [ ] Limited rice varieties
- [ ] Unaffordable irrigation facilities
- [ ] High dependence on rice alone

How would you want the government or NGOs to support your adaptation efforts?..

What innovation do you apply to improve on your incomes and food security as a rice farmer amidst climate variability in Limoto wetlands? (Open ended question)……………

……………………………………………………………………………………………………

APPENDIX 11: INTERVIEW FOR KEY INFORMANTS

I **JOSEPH KAUGULE** a student at Busitema University, pursuing a Master of science Degree in Climate Change and Disaster Management, carrying out research on the **Farmers' perception of the effect of climate variability on rice production and adaptation strategies in Limoto wetlands, Kibuku district**. I take this honor to request you to provide information to me and your responses will be treated as confidential and used for academic purposes only.

AGRICULTURE AND ENVIRONMENT OFFICERS (DPO, DAO, DFO, FORESTRY, ENVIRONMENT AND EXTENSION OFFICERS)

What enabling interventions have been put in place to improve rice farming in Limoto wetlands?

How have these enabling interventions benefited the rice farmers in Limoto wetlands?

How have you getting the climate and weather trends information to influence farming in Limoto wetlands?

How have you managed to cascade the weather and climate trends information to the rice farmers in Limoto wetlands?

What are the common obstacles rice farmers face when trying to adopt new innovation and technologies rice farming in Limoto wetlands?

WHOLE SALE AND RETAIL RICE TRADERS

How have climate change events to farmers affected the quality of the rice yields in your business?

How have climate change events to the rice farmers affected the quality of the Rice seed varieties in your business?

How have climate change conditions to the rice farmers affected the flow of income in your business?

What advice do you give rice farmers in order to improve on their rice kilograms amidst climatic change conditions?

RICE MILLERS

How is the Rice kilograms brought by rice farmers for milling in during the extended dry season in Limoto wetlands?

How is the Rice kilogram brought by rice farmers for milling in during the extended rainfall/ flooding season in Limoto wetlands?

Mention some of the rice seed types brought for milling by the farmers during the extended dry season in Limoto Wetlands?

Mention some of the rice seed types brought for milling by the farmers during the extended rainfall/ flooding season in Limoto Wetlands?

How do changes in climate events to the wetland rice farmers affect your Income flow regarding the turn up for the rice farmers for milling services?

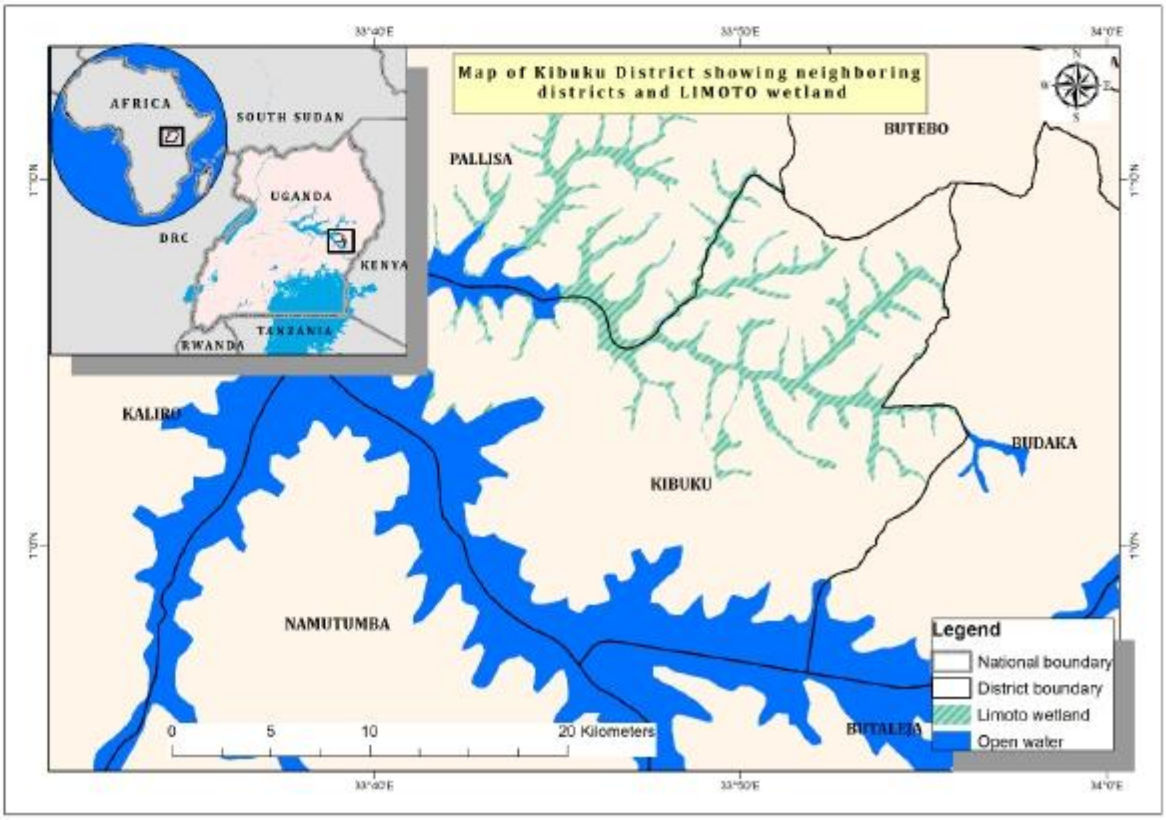
SERVICE PROVIDERS (SEED SELLERS, PESTICIDE AND HERBICIDES, AND FERTILIZER SELLERS)

What are the common rice seed varieties preferred and recommended to the rice farmers for planting in Limoto wetlands amidst climate change events?

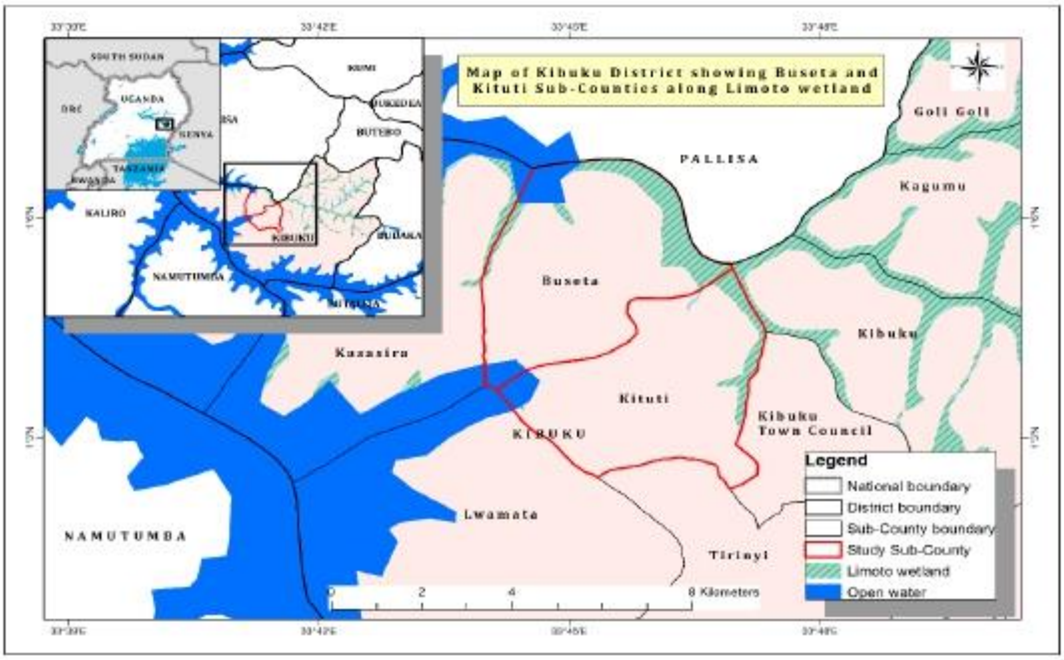
What pesticides and herbicides are preferred and recommended for use to rice farmers in Limoto wetlands during the climate change events?

What fertilizers have you always recommended the rice farmers to use during climatic change events?

APPENDIX III: Map of Kibuku District and its neighboring districts at Limoto wetland



APPENDIX IV: Map of sampled sub counties of Buseta and Kituti on Limoto wetlands



Source: Field Date

THE END

Thank you so much, may the almighty Bless you all abundantly