ASSESSING THE ROLE OF INDIGENOUS KNOWLEDGE AND PRACTICES FOR ADAPTATION TO EFFECTS OF RAINFALL VARIABILITY IN BUDUDA

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DECLARATION

I, **Martin Ojok** do hereby declare that this research report has been developed through my efforts and has not been submitted to Busitema University or any other institution of higher learning for the award of a Master's degree or any other qualification.

Signature ---------------------------------------

30/05/2025

APPROVAL

This is to confirm that this dissertation is original and has been through the efforts of **Martin Ojok** as part of his fulfillment for the award of the Master's Degree in Climate Change and Disaster Management of Busitema University, Uganda.

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DEDICATION

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Augustine Oyena and Janet Oyena whose words of encouragement and push for tenacity ring in my ears. My siblings have never left my side and are very special.

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LIST OF ACRONYMS AND ABBREVIATIONS

C	Carbon
CC	Climate Change
CH_4	Methane
CO_2	Carbon dioxide
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometre
LDCs	Least Developed Countries
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
mm	millimeter
MWE	Ministry of Water and Environment
NAPA	National Adaptation Programme of Action
NCCP	National Climate Change Policy
NEMA	National Environment Management Authority
NGOs	Non-Governmental Organizations
UBOS	Uganda Bureau of Statistics
UNMA	Uganda National Meteorological Authority
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
IK	Indigenous Knowledge
NDC	Nationally Determined Contribution
EWS	Early Warning System

ABSTRACT

This study assessed rainfall variability in Bukigai Sub County Bududa district, a factor behind rampant flooding and landslides and the role of indigenous knowledge and practices as an adaptation strategy in response to the variability. The study adopted a mixed research approach where quantitative data used included annual and seasonal rainfall from 1991-2021 sourced from UNMA. Qualitative data was collected by administering questionnaires to 100 randomly selected household members of Bukigai Sub County in the parishes of Bunamubi, Bumatanda and Bumangoye, as well as key informant interviews and observations by the researcher. Time series, regression and trend analysis were used to investigate the anomalies in annual and seasonal rainfall. Survey data was analyzed using descriptive statistics, correlation analysis and regression to determine the dominant Indigenous adaptation practicesa and the role it plays in climate variability adaptation. In addition, Probit tests were run to find the casual relationship between the use of IK as an adaptation strategy and selected socio-economic factors. Results revealed significant trends of seasonal and annual rainfall variability. 76% of the respondents believed that there was climate variability and 24% did not believe. 99% of the respondents further admitted practicing one or more Indigenous adaptation strategies to cope with the changing climate. The strategies practiced were food stocking (91%), crop diversifications (89%) and grain preservation (84%). Probit tests revealed that none of the tested socio-economic factors (age, income and education level) was statistically significant in influencing the use of IK for adaptation at 5% significance level. The probit test also gave a pseudo R^2 of 6%, meaning that the socioeconomic factors tested could only explain 6% of the variations in the respondents' engagement in use of IK.

In conclusion, the findings of this study underscored the importance of Indigenous Knowledge and practices in facilitating adaptation to climate variability in Uganda. While there is a widespread recognition of climate change impacts and a high level of engagement in indigenous knowledge and adaptation practices, socio-economic factors alone did not significantly influence the adoption of Indigenous Knowledge. Future research should explore additional contextual factors and socio-cultural dynamics that may shape adaptive behavior, in order to inform more effective and targeted interventions for building climate resilience in vulnerable communities.

CHAPTER ONE: INTRODUCTION

1.1 Background

Climate change and climate variability is one of the world's greatest challenges facing humanity in the 21st century (Pirani, 2021). This is caused by increased concentration of Green House Gas (GHG) emissions in the earth's atmosphere majorly resulting from human activities such as burning of fossil fuels and deforestation among others. In Africa, climate change manifests in form of prolonged droughts and heavy rainfall that negatively affects agriculture severely impacting on livelihoods especially in sub Saharan Africa, Southern and East Africa (UNISDR, 2013). Uganda has experienced notable climate changes over recent decades, including increased temperatures, altered rainfall patterns, and more frequent extreme weather and future projections indicate increased temperatures by 1.8^{o}C by 2050s and up to 3.7^{o}C by 2090s under high emission scenarios. Rainfall patterns are expected to be variable with increases in some regions and decreases in others, affecting agriculture and water resources among other sectors. Currently Elgon region in Uganda has experienced increased frequency and severity of floods and landslides which have devastated livelihoods in the area districts motivating a study in Bududa.

Communities for long have used changes in their environments to predict fluctuations in weather and climate. These predictions enable them plan for social activities such as feasting, weddings, fishing and hunting among others. Despite the importance attached to the predictions, little attention has been paid to documenting local environmental observations made by indigenous peoples unlike in the case of Western scientific techniques for weather forecasting (IUCN, 2008). In the context of this study, indigenous knowledge refers to the "unique, local, traditional knowledge existing within and developed around the specific conditions of a community in a particular geographic area". This body of knowledge has been accumulated over successive generations through experiential learning, comprising meticulous observations and iterative trial and error, with continuous integration of new insights (Grenier, 1998). Indigenous knowledge is routinely employed in everyday subsistence practices but may also manifest as urgent adaptive measures in response to critical climatic threats (Stott & Kettleborough, 2002). A notable intervention undertaken by these communities to mitigate vulnerability to climatic risks is the establishment of an early warning system for forecasting climate-related events (Ajibade & Shokemi, 2003). It has been demonstrated that indigenous knowledge encompasses weather and climate prediction capabilities, which have facilitated local communities' adaptation to climate variability (Mengistu, 2011). Indigenous traditions have long depended on natural indicators—

such as the blooming of wild plants, the presence of strong winds, and the appearance of various flying and crawling insects—to predict the beginning and end of rainfall (Mfitumukiza, et al., 2020). For example, shading of trees is used to foretell approach of a dry season, appearance is of frogs is used to forecast approach of a rainy season in central Uganda. Elsewhere in other regions of the country, they also have specific aspects of nature they look at to foretell weather and climate conditions.

Climate variability impact countries differently, and a society's ability to adapt is limited by a range of factors such as level of vulnerability, exposure, adaptive capacity, level of knowledge as well as culture (Adger, Arnell, & Tompkins, 2005) . Local communities have effectively adjusted to various forms of change, including those related to climate variations (Gurung & Bisht, 2014). In Uganda, local communities are already involved in different adaptive strategies in the face of climate variability in their areas (Egeru, 2011). These practices depend extensively on indigenous knowledge, which is instrumental in facilitating climate change adaptation at the community level (GoU, 2007). Previous research conducted in Soroti and Mubende districts documented effective climate change adaptation through indigenous practices, including mulching, mixed farming, intercropping, trench digging, cultivation of well-adapted crop varieties, crop rotation, afforestation, feeding livestock with stored dried grass, and the use of cow dung, which has encouraged further investigation of these methods in other regions (ESAFF, 2015).

Bududa being highly susceptible to landslides, flooding in the plains, disease outbreaks, crop losses, and decreased yields all prompting food insecurity, the communities are devising different approaches based on indigenous knowledge to cope with the changing climate. They are creating stone banks to control mudslides and erosion as well as planting trees to hold the soil firm. Integrating this knowledge into climate change policies can facilitate the creation of adaptation strategies that are efficient, inclusive, and sustainable (Robnison & Herbert, 2001).

This study therefore assessed the role of indigenous knowledge and practices as adaptive strategies to climate variability to enhance the adaptive capacity of local people in the study area. This is important as this could be mainstreamed in the sub-county and district local plans and strategic designs for climate variability adaptation for sustainable production and improved livelihoods.

1.2 Problem statement

Extreme weather events such as flooding and landslides are rampant in the Elgon sub region of Uganda, attributed to climate change and climate variability. They have been accelerated by degradation of land cover especially along mountain slopes exposing the local population to reduced crop productivity, loss of livelihoods and loss of lives in some instances. Bududa district is singled out as the most affected, experiencing more frequent and damaging floods in the region. This has negatively affected food security, social stability and sources of community livelihoods. Various scientific approaches such as developing EWS have been applied, however, community resiliency and adaptation efforts still fall short of fully addressing the problem necessitating probing the role of IK and practices as a supportive strand to increase resiliency to impacts of climate variability.

The National Adaptation Program of Actions (NAPA), emphasizes the adoption of indigenous knowledge and practices to rainfall variability. Recommended practices include terracing, tree planting, crop diversification, rain water harvesting and mixed cropping among others (Kihila, 2018). The Uganda National Climate Change Policy stresses the need to integrate climate change and climate variability in sector plans and budgets. However, Indigenous Knowledge is rarely taken into consideration in the design and implementation of modern mitigation and adaptation practices and, is faced with the growing perception of being obsolete and inefficient among the current generations yet indigenous practices require minimal technical capacity and investment. Ignoring such practices in favour of scientific approaches like in organic fertilizer application for addressing climate variability can be counterproductive in the long run for sustainable development.

This research therefore assessed the effectiveness of Indigenous Knowledge and practices as a response measure to rainfall variability in Bukigai Sub County, Bududa district in Uganda.

1.3 Objectives

1.3.1 General objective

The general objective of the study is to assess the impact of indigenous knowledge and practices as adaptation strategies to effects of rainfall variability in Bukigai Sub-County, Bududa district.

1.3.2 Specific objectives

The study was informed by the following specific objectives.

i. To describe the trends of rainfall in Bukigai Sub County, 1991-2021.
ii. To evaluate the effectiveness of Indigenous Knowledge and practices as response measures to effects of rainfall variability.
iii. To assess the influence of gender, age, household size and income in adoption of Indigenous Knowledge and practices in response to rainfall variability.

1.4 Research questions

The following research questions were used for the study.

1) How has rainfall varied over time in Bukigai Sub County, Bududa district?
2) What is the effectiveness of existing Indigenous Knowledge and practices in Bukigai Sub County used to respond to the effects of rainfall variability?
3) How has gender, age, household size and income influenced the adoption of indigenous knowledge and practices in response to the effects of climate variability?

1.5 Significance of the study

This study bridges knowledge gap on the different indigenous knowledge and climate variability adaptation practices used by the Bukigai communities. Furthermore, the study identifies priority adaptation strategies practiced in the study area. Focusing the study is very important as climate variability affects regions differently, and understanding the local context is crucial for developing effective adaptation strategies (NDCs, 2015). Therefore, this research provides insights that are directly applicable to the Ugandan context, helping policymakers both at national and at local government, civil society organizations and other actors to formulate and or cause policy shifts by developing more sustainable and locally appropriate adaptation strategies, more inclusive and taking into account the wealth of knowledge present within indigenous communities to increase resiliency to climate change impacts.

This research contributes to the preservation and recognition of indigenous knowledge. This is crucial for maintaining cultural diversity and ensuring that traditional practices are not lost over time. Involving local communities in the research process and recognizing the value of their knowledge can empower these communities. It fosters a sense of ownership and agency in dealing with the effects of climate variability.

While the focus is on Uganda, the insights gained from this research may have broader implications for other regions facing similar challenges. It adds to the global body of knowledge on climate change adaptation, providing a case study that can be referenced and adapted in other parts of the world.

1.6 Scope of the study

Bududa district is located in the Eastern Region of Uganda, bordering the Republic of Kenya in the East; Sironko district in the North; Mbale district in the west; and Manafwa district in the south. It lies between the longitudes of 34º 16´ 18" and 34º 32´ 6.69" East, and latitudes 00º 58´ 45.63" to 1º 7´ 22.07". Its average altitude is 1,800 meters above sea level. The district has a land Area of 273.79 km^2 and this represents 1 percent of Uganda's total land Area (UBOS, 2014). The district is characterized by mountainous topographies and is prone to floods and landslides (NEMA, 2008). The Bamasaba dominate the indigenous population and constitute 98 percent of the total population of 157,700 people.

1.7 The conceptual frame work

This study adopted the conceptual frame work in Figure 3.

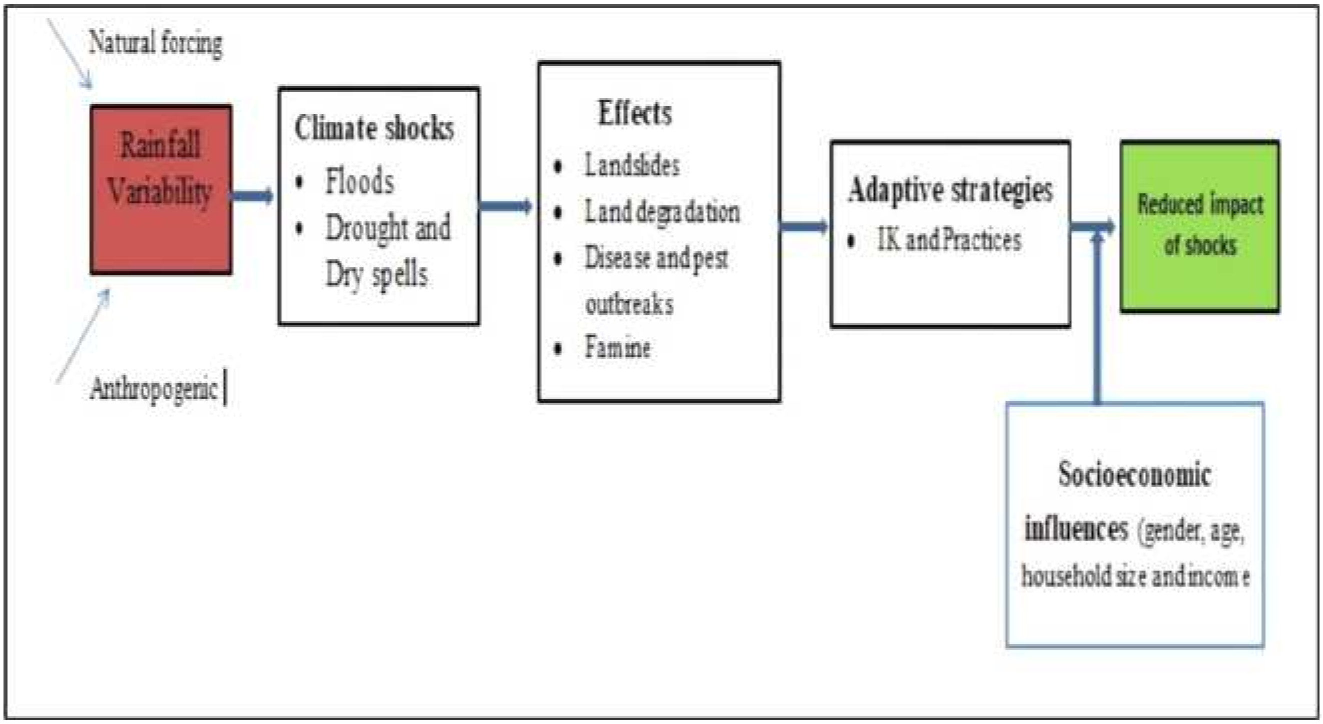


Figure1. Conceptual framework developed for this study. Note: IK means indigenous knowledge

From the conceptual frame work in Figure 1, the research problem to address is rainfall variability which is attributed to both natural climate forcing such as changes in solar outputs, volcanic outgassing and anthropogenic activities such as deforestation, bush burning, excessive use of inorganic fertilizers (nitrates) and mining among human activities (Keely, 2010). Rainfall variability results into hazards such as floods and droughts. These negatively impact almost all sectors of the economy, for example droughts result into crop failure which threatens food security. Floods destroy gardens, destroy property and may cause death. To reduce these associated negative impacts necessitates developing community resiliency by adopting use of both indigenous knowledge, practices and modern knowledge and practices.

In Figure 1, social-economic factors are the independent variables whereas indigenous knowledge and practices are the dependent variables.

CHAPTER TWO: LITERATURE REVIEW

2.1 Climate change, climate variability, vulnerability and adaptation

To fully understand climate change, it is essential to distinguish between weather and climate. Weather describes the current state of the atmosphere at a given location, including elements such as precipitation, temperature, wind, and sunlight. Conversely, climate refers to the long-term average of daily weather patterns measured over a period of 30 years (Planton, 2013). The Inter-Governmental Panel on Climate Change (IPCC) defines climate change as: “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (ISDR, 2009).

To the contrary, UNFCCC defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”. It occurs when changes in Earth's climate system result in new weather patterns that last for at least a few decades, and maybe for millions of years(IPCC, 2013).

According to the IPCC’s 5th Assessment Report, 2014, 95% climatic changes are human induced. Human activities can change earth's climate, and are presently driving climate change through global warming (IPCC, 2009). The rapid rise in the world’s population and our ever-growing dependence on fossil fuel-based modes of production has played a considerable role in the growing concentration of greenhouse gases in the atmosphere. As a result, global temperatures are increasing, the sea level is rising and precipitation patterns are changing, while storm surges, floods, droughts and heat waves are becoming more frequent and severe. Subsequently, agricultural production is decreasing, freshwater is becoming scarcer, infectious diseases are on the rise, local livelihoods are being degraded and human well-being is diminishing (Gleb, 2011). Climate variability on the other hand refers to fluctuations of climate above and below the long term mean. It can take a form of monthly, seasonal or annual fluctuations. Climate variability manifests in form of long dry spells, droughts, floods and hailstorms among other forms.

Vulnerability: The Least Developed Countries (LDCs) and Small Island Developing States are recognized as the most susceptible to the negative impacts of climate change (IPCC, 2007).

Most of these economies directly dependent on weather patterns, and so climate variability has direct implications (IPCC, 2014). According to the National Adaptation Programmes for Action report of Uganda, increased droughts, shift in rainfall patterns, floods, landslides in hilly areas and waterborne disease outbreaks have been experienced in recent years (Orindi & Eriksen, 2005). In Uganda's cattle corridor experienced severe and prolonged droughts in the years 1999 and 2000, leading to livestock deaths, low milk and food production and malnutrition (Ben, Carla, Merit, & Abushen, 2009). Future projections indicate increased frequencies and duration for these droughts in the near and late century (IPCC, 2022).

Adaptation is the process of adjusting social and natural systems to reduce their vulnerability to human-induced climate change and climate variability(IPCC, 2009). This involves making changes based on actual or expected climate conditions to minimize harm or benefit from new opportunities. For example, farmers may adopt drought-resistant crops to manage the challenges posed by irregular rainfall (ISDR, 2009).

Adaptation holds significant importance in developing countries, as many are expected to experience the greatest impacts of global warming (Cole, Gine, Tobacman, Topalova, Townsend, & Vicker, 2009). The financial burden of adapting to climate variability is projected to reach billions of dollars each year over the coming decades, although the exact cost remains uncertain. Africa is regarded as the most vulnerable continent because of its high exposure to climate risks and limited ability to adapt (IPCC, 2014).

Adaptation is specific to place and context, with no single risk reduction approach suitable for all settings. 'Adapting to climate change entails adjustments and changes at every level, from community to national and international levels' (UNFCCC, 2007).Adaptation can take various forms depending on the response to an external threat (Burton, Smith, & Lenhart, 1998). This indicates that if actions are taken before the threat, the adaptation is preventive; if actions occur during the threat, the adaptation is gradual and short-term. However, if the action is taken after the threat, the adaptation is reactive. The ability of households and communities to adapt to climate fluctuations depends on their level of resilience. Local governments must coordinate adaptation initiatives by safeguarding vulnerable populations, promoting economic diversification, offering information, establishing policy and legal frameworks, providing financial assistance, and enhancing community adaptation efforts (IPCC, 2014).

2.2 Indigenous knowledge and its relevance in adaptation to rainfall variability

According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2020), indigenous knowledge is defined as the understandings, skills, and philosophies developed by communities through long-term interaction with their natural environment. For rural and indigenous peoples, this knowledge guides decision-making in everyday life. It is part of a wider cultural system that includes language, classification methods, resource use, social relationships, rituals, and spirituality. These unique knowledge systems are important aspects of the world's cultural diversity and provide a foundation for sustainable development that is locally appropriate

Indigenous Knowledge (IK) is defined by Kelman et al. (2012) as local or traditional knowledge originating from local communities. In comparison, Agrawal (1995) describes Indigenous Knowledge as knowledge passed down through generations, gained from a deep understanding of the environment, and often revealed through intuition, dreams, or visions. While Kelman's definition focuses on the community source of the knowledge, Agrawal emphasizes its generational transmission and spiritual elements. This study adopts the definition by Kelman et al. (2012).

Indigenous Knowledge is widely used as an adaptation strategy to cope with rainfall variability among communities in sub-Saharan Africa (Ajani, Mgbenka, & Okeke, 2013). There exists extensive local knowledge related to weather and climate prediction. Research on weather knowledge across different regions of sub-Saharan Africa highlights the deep understanding farmers have developed. These farmers have created complex methods for collecting information, forecasting, interpreting, and making decisions based on weather conditions.

The local communities in the region through the indigenous knowledge systems have developed and implemented extensive adaptation practices like looking at cloud colour and direction to tell area of potential rainfall, sighting of certain plants and animals like appearance/disappearance of frogs to tell the onset/cessation of rains, environmental odour indicating upcoming season, dark sky indicating onset of rainfall and clear sky in the early hours of the day indicating long day sunshine. This knowledge has helped decrease vulnerability to rainfall variability and climate change over time (Ajibade & Shokemi, 2001). Farmers rely on observations of birds, insects, plants, animals, wind direction, and astronomical signs to forecast weather patterns (Elia, Mutula, & Stilwell, 2014).

A study conducted in the Kingdom of Eswatini highlighted the significance of involving Indigenous and local communities and integrating Traditional Knowledge into the National Adaptation Plan (NAP) process (Samkele Tfwala, 2023). Indigenous knowledge functions at a much more detailed spatial and temporal scale compared to scientific approaches and encompasses ways to manage and adapt to environmental variability and trends. Therefore, Indigenous knowledge plays a vital role in climate change policy and contributes to Sustainable Development Goal 13 on Climate Action by monitoring climate changes, adapting to their effects, and supporting global mitigation efforts (SDGS, 2020).

Governments and policymakers have developed and implemented climate adaptation plans rooted almost exclusively in scientific knowledge. These plans have consistently ignored or omitted the knowledge and expertise developed by indigenous communities themselves, despite the fact that these communities are the ones grappling with and adapting to the effects of climate fluctuations on a daily basis (Karki et al., 2017). Incorporating indigenous knowledge into modern adaptive strategies is an untapped opportunity that can be mutually beneficial to both the communities and policymakers who must deal with a changing planet (Balaji, 2019).

In Africa, indigenous and local knowledge plays a crucial role in improving the resilience of communities that are highly vulnerable to the impacts of climate change (Orlove, Roncoli, & Kabugo, 2009). The inclusion of farmers' knowledge and practices in the actions that governments take in relation to adaptation is a step towards enhancing the resilience and adaptation (Thaman, Lyver, Mpande, Perez, Carino, & Takeuchi, 2013). Earlier research conducted in Soroti and Mubende districts identified a variety of indigenous methods that farmers use to adapt to climate change. These include mulching, mixed farming, intercropping, crop diversification, trench digging, cultivation of well-adapted crop varieties, crop rotation, afforestation, feeding animals with stored dried grass, use of compost manure or cow dung, planting drought-resistant crops, and early maturing crop varieties. These practices have demonstrated their effectiveness in coping with the challenges posed by climate variability (ESAFF, 2015).

While indigenous peoples' traditional low-carbon lifestyles have minimally contributed to climate change, they suffer the most severe impacts. This is mainly due to their long-standing reliance on local biodiversity, ecosystem services, and cultural landscapes for their survival and well-being (Gleb, 2011).

Some members of Bukigai Sub County communities utilize Indigenous Knowledge (IK) systems and practices to adapt to climate change and reduce associated risks (Egeru, 2012). These knowledge systems are highly localized and vary among households, being applied for diverse purposes including medicinal use, weather forecasting, climate predictions, and disaster risk reduction (Mugambiwa, 2018). Indigenous climate forecasting has proven particularly valuable in helping communities manage their vulnerability (Karki et al., 2017). Decisions about cropping patterns and planting dates are informed by local weather predictions derived from complex cultural models. Additionally, indigenous knowledge plays a critical role in biodiversity conservation, a key adaptation strategy. However, modernization, urban migration, changing landscapes, and shifting religious beliefs threaten the survival of IK, highlighting the urgent need for its documentation and integration with scientific knowledge. It is crucial to preserve the distinctive qualities that differentiate IK while fostering collaboration with scientific approaches to ensure acceptance among researchers and policymakers

2.3 Indigenous knowledge visa vis scientific knowledge

Our current understanding of the climate crisis is mainly based on scientific knowledge, which uses Western methods focused on data, experiments, and research from different fields (Alexander, et al., 2011) This science has produced global reports and research that guide international climate policies. These findings show clear evidence of Earth's warming, caused by increased greenhouse gases, leading to problems such as rising sea levels, flooding, food shortages, drought, ocean changes, and loss of wildlife (IPCC, 2014). Despite the widespread acknowledgment of these issues and scientific consensus on their human causes, warnings and international efforts have not resulted in sufficiently effective policies to reduce emissions and combat climate threats. Scholars have identified several limitations in this scientific approach, including manipulation of uncertainties, the globalizing of environmental threats, neglect of local contexts, externalizing the environment, and marginalizing alternative perspectives and knowledge systems (Alexander, et al., 2011).

Science faces difficulties in precisely forecasting climate changes at local levels (Nerlich, Koteyko, & Brown, 2010), and some use these uncertainties to oppose climate action and delay policy implementation (Lomborg, 2010). While scientific research has provided valuable and groundbreaking insights into climate change, the gap between understanding the crisis and implementing effective measures reveals its limitations. Therefore, incorporating alternative knowledge systems, such as indigenous knowledge, is essential to expand perspectives and develop more effective climate responses (Alexander, et al., 2011) .This is the reason why this study focuses on indigenous knowledge as a strategy to address climate variability in Bukigai Sub County, Bududa district.

2.4 Indigenous knowledge indicators

Local people possess deep knowledge of the land and sky, making them skilled observers and interpreters of changes in the climate system and environment (Egeru, 2011). The community-based and collectively held knowledge they develop offers valuable insights that complement scientific data by providing detailed, chronological, and landscape-specific information. This level of precision is crucial for validating climate models and assessing scenarios created by scientists at much broader spatial and temporal scales. This perspective is further supported by a study on traditional and indigenous knowledge for climate change adaptation in Swaziland (Samkele Tfwala, 2023).

In the Sahel, farmers have developed complex systems to collect data, predict weather, interpret signals, and make decisions. These climate forecasting methods have been instrumental in helping them manage their vulnerability. They often base their cropping choices on local climate forecasts and select planting times according to sophisticated cultural weather models (Gyampoh, Amisah, Idinoba, & Nkem, 2014).

Strengthening and promotion of indigenous knowledge as an adaptation response to climate variability fosters trans- disciplinary engagements with scientists and policy-makers to further understand its impacts especially in strengthening community resilience and promotion of sustainable development. These engagements also build synergies that improve efficiency and effectiveness of adaptive strategies.

2.5 Indigenous adaptation practices

Existing literature on indigenous and local knowledge offers strong evidence that indigenous peoples and local communities have, for generations, adapted to climate-related hazards and risks by creating livelihood practices tailored to their specific contexts and strengthening the resilience of their households and communities(Karki et al., 2017). This view is supported by a study on traditional and indigenous knowledge for climate change adaptation in Eswatini (Samkele Tfwala, 2023).

A large portion of indigenous knowledge has been acquired through the long-standing practices of shifting cultivation and traditional livelihoods, closely connected to living in harmony with nature (Martha, Thomas, Hendrik, Jan, & Afif B., 2016).For example, pastoralists use emergency fodder during droughts, maintain herds with multiple species to withstand climate extremes, and cull weaker animals for food when droughts occur (Gyampoh, Amisah, Idinoba, & Nkem, 2014).

In Ghana, farmers have long employed various adaptation strategies in response to rising climate-related shocks and stresses, including permanent and seasonal migration, introducing new crop varieties, adopting irrigation techniques, and adjusting planting dates (Tambo, 2016) Similarly, many farmers across sub-Saharan Africa also use the adjustment of planting dates as a common adaptation method (Wahaa, Muller, Bondeau, Dietrich, Kurukulasuriya, & Heinke, 2013).

In Uganda, communities have long adapted to climate variations through a range of strategies. A study conducted in Mubende and Soroti districts revealed that smallholder farmers have employed various indigenous practices such as mulching, mixed farming, intercropping, crop diversification, trench digging, and crop conservation (ESAFF, 2015) .The study also highlighted the use of compost manure to enhance soil fertility, the cultivation of drought-resistant crops, and dietary adjustments. These measures aim to control soil erosion, improve food security, and establish sustainable income sources to better cope with climate variability.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Research Design

This study used both qualitative and quantitative methods. Quantitative data (rainfall) was obtained from Uganda National Meteorological Authority (UNMA) for trend analysis to address objective one whereas qualitative data was collected using semi structured questionnaires and key informant interviews for analysis to address objective two and three.

3.2 Study Area

This research was conducted in Bududa district (Figure 2). The major source of income in Bududa district is smallholder agriculture especially crop production. The main crops grown are coffee, bananas, yams, cabbages, maize, beans among others (UBOS, 2014).

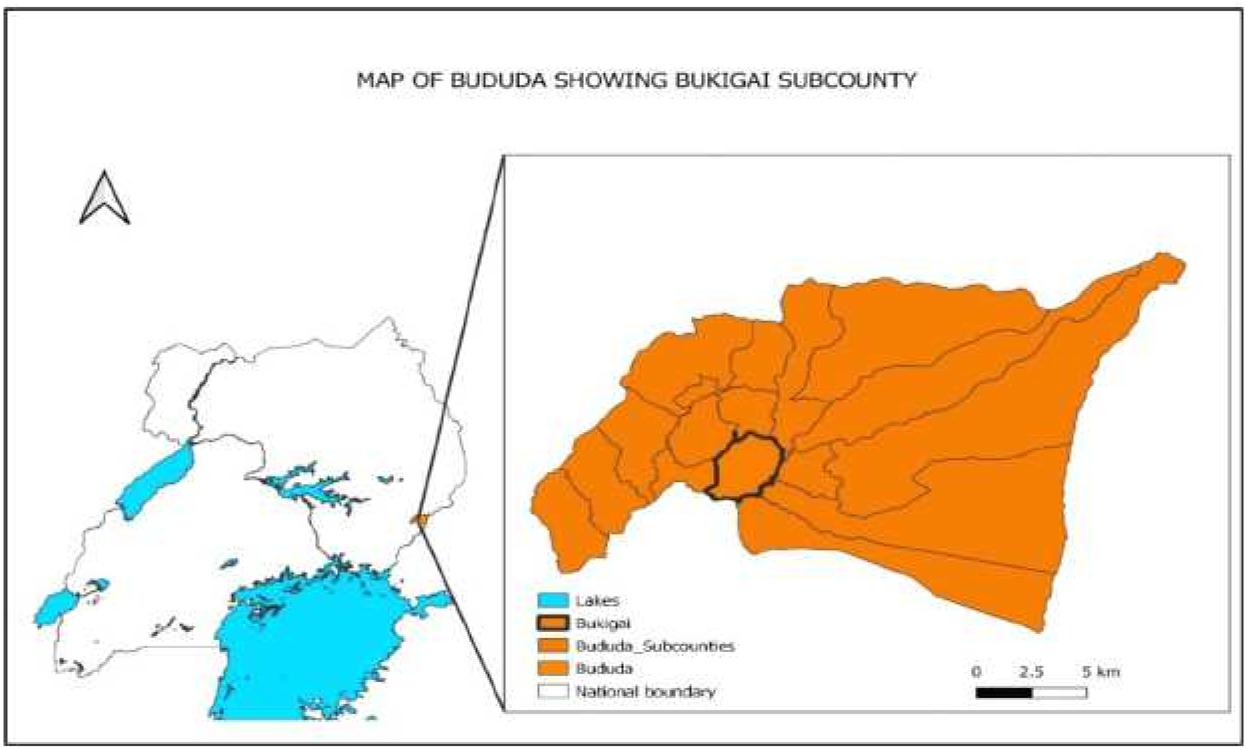


Figure 2. Location of the study area- Bukigai Sub County, Bududa district

Bukigai Sub County, Bududa district was purposively selected for this study due to the high frequency of climate related disasters such as landslides due to heavy and above normal rainfall, reduced soil fertility resulting into low crop productivity as compared to the past. Besides the existence of climate related disasters, the community in the area is already engaged in different indigenous practices for adaptation to the variability in climate for food security, continued production for incomes and livelihood development. This calls for a need to explore and document this indigenous knowledge based practices for climate fluctuation adaptation in the area and neighboring communities especially amongst the farming communities.

The district experiences a bimodal rainfall pattern, with the majority of precipitation occurring in April and October (Mbogga, 2012). Between these two rainy seasons are two dry periods: one from June to July and a longer one from December to March (GIZ, 2020). December and January are usually the driest months (WBG, 2021). Annual rainfall ranges from 1,200 to 2,700 mm, depending on altitude, although 2007 recorded an unusually high amount of rainfall (Bomuhangi et al., 2016).

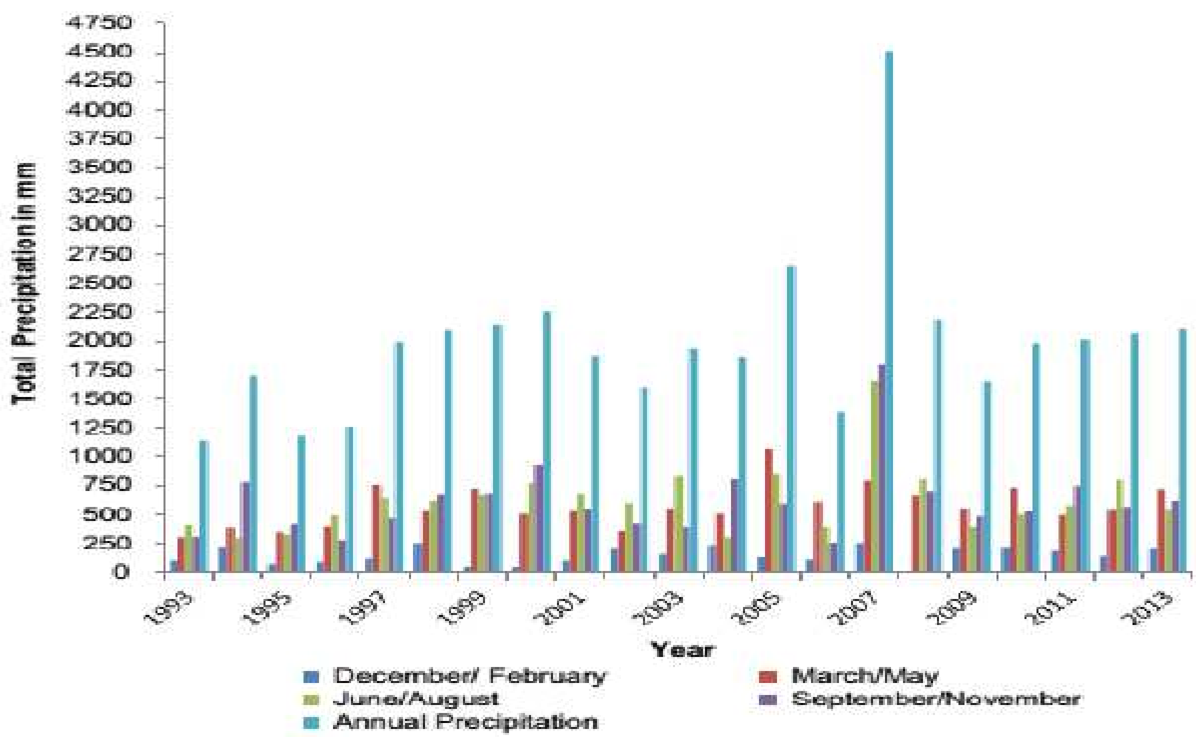


Figure 3. Trend of seasonal and annual precipitation in mm for Mt. Elgon region, Buginyanya Meteorological station (Source: Bomuhangi et al., 2016).

The average yearly temperature is approximately 23.2°C, with an average low of 15°C and an average high of 29°C, as indicated in Table 3.1. The warmest months are January, February, and March, while July and August are the coolest months (Bamutaze, et al., 2010).

Table 3. 1 Trend of annual temperature in (0 C) in for Mt. Elgon region

Year	Mean annual maximum (C^0)	Mean annual minimum (C^0)	Mean annual (C^0)
1993	30.33	17.08	23.70
1994	29.24	16.80	23.02
1995	29.86	17.05	23.45
1996	26.49	16.97	23.23
1997	29.28	16.76	23.02
1998	29.07	16.63	22.85
1999	29.97	17.38	23.68
2000	29.38	17.02	23.20
2001	29.74	15.98	22.86
2002	29.94	16.88	23.41
2003	29.92	16.80	23.36
2004	29.98	16.74	23.36
2005	30.51	17.98	24.25
2006	29.65	17.74	23.70
2007	29.47	17.50	23.48
2008	29.68	16.98	23.33
2009	30.23	17.37	23.80
2010	29.69	16.89	23.29
2011	29.32	16.88	23.10
2012	29.20	16.94	23.07
2013	29.32	16.87	23.09
Source: Buginyanya Meteorological data, adopted from (Bomuhangi et al., 2016).			

The district lacks significant natural vegetation in its populated and arable areas, where farmland cultivating matooke and vegetables is the primary vegetation type (UBOS, 2014). Outside these settled zones, tropical forests cover approximately 40 percent of the district, followed by bamboo forests and, at the mountain summits, areas of moorland and ferns. Most of the district's vegetation transitions from tropical forest to alpine vegetation near the mountain peaks

The district’s soils originate from three main lithological zones. The central area, corresponding to Bukigai Sub-county, is dominated by Butiriku carbonatite. This is surrounded by a ring of fenitized Precambrian basement rocks. In the northeast of Bududa District lies the third zone, composed of Mount Elgon agglomerates and tuffs. These highly weathered rocks consist of very fine pyroclasts of potash feldspar, referred to as potash ultra-fenites (Knapen et al., 2006). Formed on volcanic parent material, the soils are generally fertile. The predominant soil types include Fluvisols, Acrisols, Nitisols, and Ferralsols.

The content scope for this study was limited to rainfall variability in terms of anomalies and trends as well as Indigenous Knowledge and practices and how these are influenced by selected socioeconomic factors.

Study Population

The 1991 national population census estimated Bududa District's population at 79,200, with a population density of 316 persons per square kilometer. By the 2002 census, the population had risen to 123,100, reflecting an annual growth rate of 4 percent, and the density had increased to 490 persons per square kilometer. In 2012, the district's population was estimated at 180,600 (UBOS, 2014).The 2014 national census recorded a population of 210,173, with a population density of 837 persons per square kilometer (UBOS, 2014).

The district is largely occupied by the Bagisu (UBOS, 2014). The Bagishu are as well referred to as the Bamasaba; the name of their founding father.

3.3 Sampling strategy and sample size

A sample used for this study was drawn from selected 3 parishes out of the 7 parishes that make Bukigai Sub-county, Bududa district. This selection was done using simple random sampling strategy. The key informants including the Sub County chiefs, agricultural officers and environmental officers were selected using purposive sampling strategy. This is because these were thought to be knowledgeable about the subject matter and were in constant touch with local communities.

The sample size for this study was determined using Slovin's formula (1960);

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

Where N = Population size n = sample size e = significance level 0.1

Bukigai Sub County population size (N) = 17,739 (UBOS, 2014)

Sample size (n) = $17{,}739/(1+17{,}739e^2)$

$= 17739/178.39$

$n = 100$

Determining the sample size is a crucial issue because samples that are too large may waste time and resources, while samples that are too small may lead to inaccurate results.

3.4 Data used

3.4.1 Type and sources

This research used both primary and secondary data. Primary data was collected using key informant interviews, survey questionnaire and observation methods. Secondary data (Rainfall), from 1991 to 2021 was sourced from UNMA for climate analysis. Other secondary sources of data were online databases such as Google scholar, national state of climate reports and desk reviews on existing literature about the study area.

3.4.2 Data collection methods

Key informant interviews

This method was used to obtain qualitative data from individuals in key positions in the community especially the agricultural and environmental officers, extension officers, plus the Sub County and parish chiefs. These were selected purposively based on the assumption that they are knowledgeable about indigenous knowledge and practices in their areas of jurisdiction. They were interviewed on indigenous practices that locals adopt in response to climate variability. The key informant interview tool is attached in the appendix.

Survey questionnaires

Questionnaires were used to obtain demographic data about the respondents including their age, education status, gender, level of income, indigenous knowledge indicators, and adaptation strategies to climate variability. Both closed and open-ended questions were set and then questionnaire administered to the survey respondents. Closed ended questions were answered by making a choice (s) amongst the different set options. For open ended questions, the survey respondents answered each question in their own words. This approach was preferred because it is relatively cheap and many respondents can easily be reached out. Additionally, this method has a higher response rate as opposed to online surveys for example due to its interactive nature.

Observation method

Participant observation is a data collection technique where the researcher gains understanding of a community's activities by both observing and actively taking part in them (Kawulich, 2005).

The researcher used this method to capture information on indigenous adaptation practices and later compared observations with responses from respondents. This method is useful in exploring facts that respondents may not be willing to reveal in the questionnaire and other interactions. Interview respondents may give a researcher what they think he wants to hear, rather than the truth which affects reliability of results (Peters, 2002). Therefore, this approach serves the purpose of collecting data to validate responses from the study respondents.

3.5 Data analysis

3.5.1 Objective 1: To describe the rainfall variability and trends in Bukigai Sub County, 1991-2021

Rainfall data for Bukigai Sub-Country, Bududa district was normalized and analyzed using Stata 14 software. This was done to remove inconsistencies using the formula Z= $(x\text{-u})/\delta$, where z is the normalized value, x is point rainfall, u is mean and δ is standard deviation. Time series plots, Regression and trend analysis were done to investigate the anomalies in rainfall over the years and within the cropping seasons for both past and present times.

To determine how the rainfall has been varying in time, a line graph of total annual precipitation was plotted using MS Excel 2016 and the trend was investigated for significance using Mann-Kendall trend analysis (Mann, 1945; Kendall 1975). This is a rank-based non-parametric method that checks the existence of trend in a time series against the null hypothesis of no trend) using the XLSTAT plugin (Xing, et al., 2018). Standardized MK trend statistics is calculated using the mathematical expression;

$$S = \sum_{k=1}^{n=1} \sum_{nj=k+1} sgn\ (X_j - X_K) \text{ ………………………………………(1)}$$

where x_i and x_j are sequential data for the i_{th} and j_{th} terms, n is the sample size and

$$sgn\ (x_j - x_i) = \begin{cases} 1 \\ 0 \\ 1 \end{cases} \text{ ……………………………………………………..(2)}$$

A hypothesis is set as follows; H_0 null hypothesis signifies no trend. Alternative hypothesis, H_1 indicates the presence of trend, either increasing or decreasing monotonic trend. The variance was calculated using the following equation

$$\text{Var}(S) = \frac{n(n-1)(2n+5)}{} \text{ ……………………………………(3)}$$

The probability associated with *S* and the sample size n was calculated to assess the significance of the trend. The scores of Z values also show the significance of the trend where the negative and positive scores of Z values denote downward and upward trends respectively. A two-tailed test, at a given α=0.05 level of significance, H_1 was accepted if $|Z| > Z_{1-\alpha/2}$ where $Z_{1-\alpha/2}$ is calculated from the standard normal distribution tables. The probability associated with MK and sample size *n* was computed to statistically quantify the significance of the trend. The normalized test statistic was calculated as below;

$$Z = \frac{s-1}{\sqrt{}} \quad \text{if } s > 0 \quad \ldots\ldots(4)$$

$$= 0 \text{ if } s = 0$$

$$= \frac{s+1}{\sqrt{}} \quad \text{if } s < 0$$

The trend is said to be decreasing if Z is negative and the computed probability is greater than the level of significance. The trend is said to be increasing if the Z is positive and the computed probability is greater than the level of significance. If the computed probability is less than the level of significance, there is no trend.

Results of rainfall anomalies (variability) and trends were presented using time series plots on which trend lines were plotted.

3.5.2 Objective 2: To examine the existing Indigenous Knowledge and practices to address climate variability.

In order to achieve this objective, qualitative approaches were used in the data collection and analysis. Collected data was arranged in themes to systematically identify, analyze, and interpret patterns of meaning within the data, to gain insights into the diverse ways indigenous communities perceive and respond to climate variability as adopted from Braun & Clarke (2006). Quantitative methods were utilized to complement qualitative findings and to provide numerical data on specific aspects of Indigenous Knowledge and practices related to climate variability. Survey data was used to gather quantitative data on the prevalence and frequency of certain practices, as well as community perceptions of climate variability as used in Dillman et al., (2014). Statistical analysis techniques employed included descriptive statistics, correlation analysis, and regression analysis to identify patterns, trends, and relationships within the quantitative data, shedding light on the effectiveness and relevance of traditional knowledge in addressing climate variability.

The qualitative and quantitative findings were integrated together to gain a comprehensive understanding of Indigenous Knowledge and practices in relation to climate variability.

3.5.3 Objective 3: To assess the influence of selected socio economic factors in adoption of Indigenous Knowledge and practices in response to rainfall variability.

In order to achieve this objective, a mixed-methods approach to data analysis was used. Thematic analysis was used to uncover patterns and themes within qualitative data obtained from surveys and interviews. Thematic analysis involved systematically identifying and interpreting patterns of meaning within the narratives of participants in order to gain insights into the factors influencing the adoption of Indigenous Knowledge and practices. This method was adopted from Braun & Clarke, (2006).

Statistical analysis was used alongside qualitative methods to examine how socio-economic factors influence the adoption of Indigenous Knowledge and practices. Numerical data collected through surveys and structured interviews were analyzed using descriptive statistics, correlation, and regression analysis to identify significant relationships and predictors of adoption behavior, following the approach of Creswell & Creswell (2017). Correlation and regression analyses quantified the strength and direction of associations between socio-economic variables—such as income, education, and employment status—and levels of adoption, defined by the use or acceptance of specific technologies or behaviors. The selection of regression models was based on data characteristics, with linear regression applied to investigate linear relationships between variables (Hair et al., 2018).

3.6 Ethical consideration

An introduction letter was provided to the researcher from the University to present to the Sub County chief to grant permission to conduct the study in Bukigai Sub County. All respondents who participated in the survey consented to participating in the survey after understanding the purpose of the study. Their views were treated with utmost confidentiality and their particulars were kept a secret/anonymous.

3.7 Culture and gender implications

Prior to data collection, the team consulted cultural leaders to ensure that they abide by the community cultural norms. Women and other socially marginalized groups, such as people with disabilities, the elderly were all encouraged to participate in this study

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Rainfall anomalies and trends

Time series plots used to analyze annual and seasonal rainfall anomalies (variability) and trends from 1991-2020 are shown in subsequent figures. The inter-annual and seasonal rainfall anomalies show the variability during the cropping seasons March to May; MAM and September to November for Bukigai Sub County, Bududa district.

The inter-annual rainfall anomalies and trends are shown in Figure4.

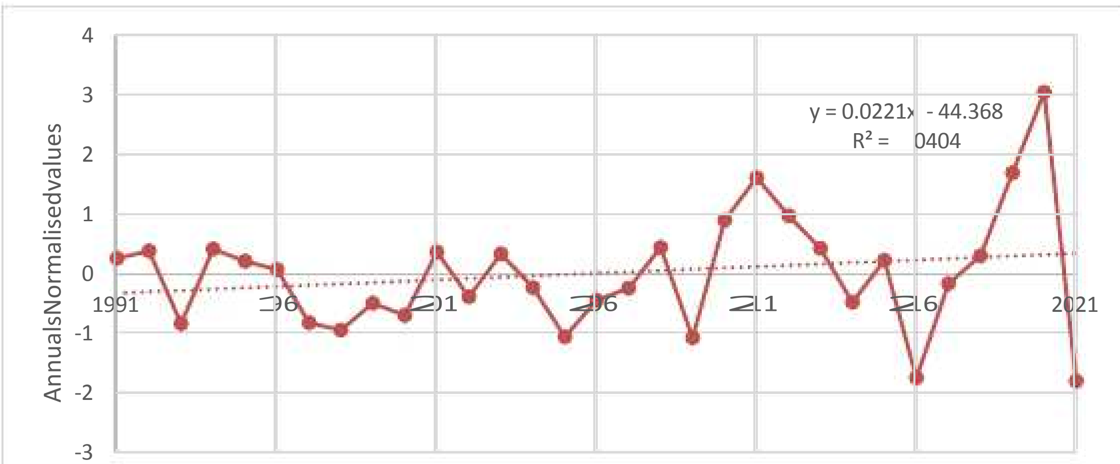


Figure 4: Annual Rainfall trends (normalized, Z-values) for Bukigai sub-county 1991-2021

The annual rainfall depicts a fluctuating pattern above and below the mean. Fluctuations below negative one (-1) from the mean reveal years of drought and dry spells whereas fluctuations above positive one (+1) imply years of flooding. The years 2011, 2019 experienced moderate rainfall whereas 2020 experienced severe rainfall. These moderate to severe rains caused floods, landslides, and crop destruction and population displacement among other challenges. The years 2016 and 2021 experienced moderate droughts which were associated with crop failure, famine and limited water resources. The annual rainfall trend showed a slight increase in rainfall over the years from 1991-2021.

Results for inter MAM rainfall anomaly and trend are shown in Figure

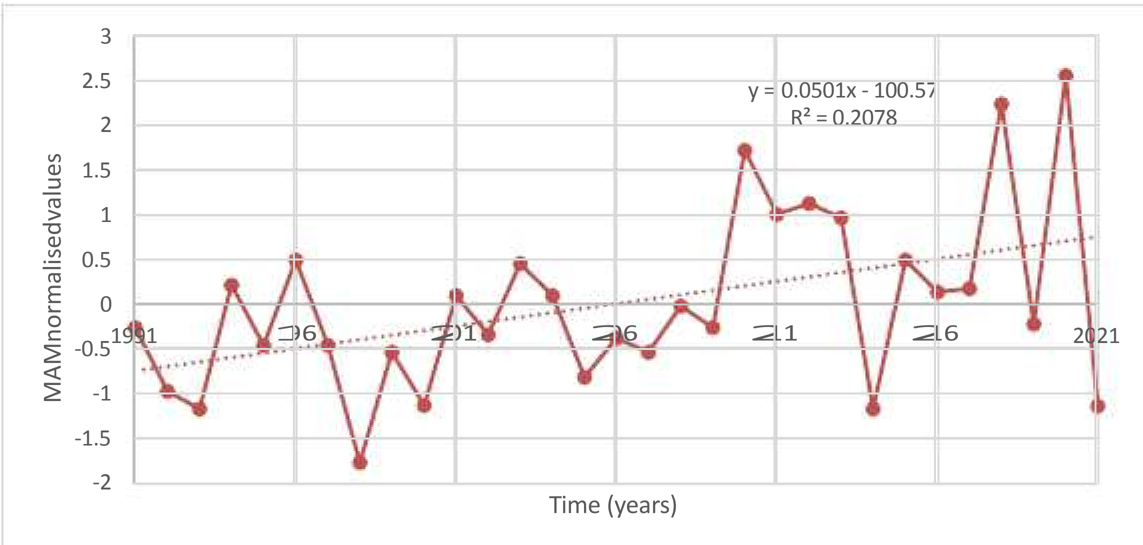


Figure 5: MAM Rainfall trends (normalized, Z values) for Bukigai sub-county 1991-2021

The inter-seasonal rainfall anomalies studied for the reference period show variability during the cropping season of MAM.

The MAM season in the years 1993, 2000, 2014 and 2021 depicted moderate drought in three months. (-1.0 to -1.5). This condition usually negatively affects agricultural productivity. The MAM season for 1998 depicted moderate drought.

The MAM rains experienced in 2010, 2018, and 2020 were severe, resulting in flooding landslides, erosions and crop damage that would eventually cause hunger and famine, malnutrition and poverty.

The trend line indicated a gradual increase in MAM rainfall over the study period, at a rate of 0.05 mm per year. Regression analysis at the 5% significance level confirmed that this trend was statistically significant, with a P-value of 0.009 (less than 0.05).

Analysis of SON rains over the years revealed results in Figure 6.

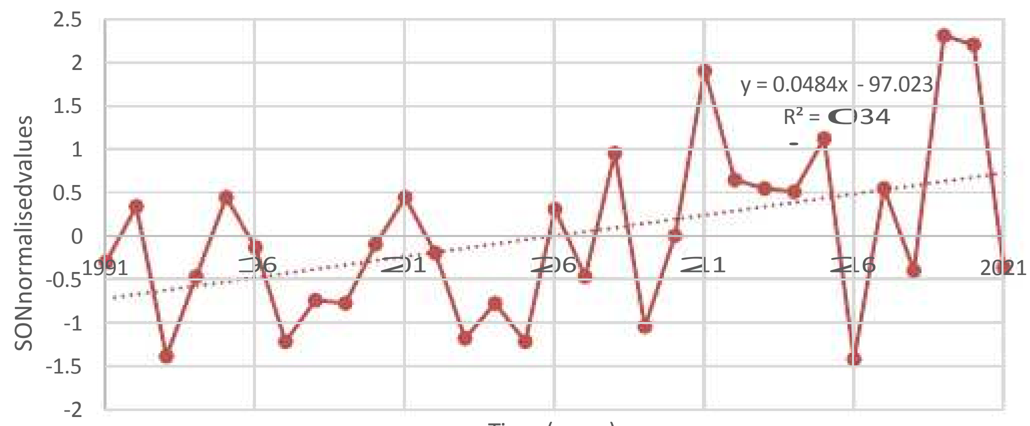


Figure 6: Normalized SON rainfall trends for Bukigai sub-county 1991-2021

The inter-SON seasonal rainfall anomalies studied from 1991 to 2020 within Bukigai Sub County, Bududa district showed great variation. The SON cropping seasons of 2008, 2012, 2015 were moderately wet whereas the SON seasons for 2011, 2019 and 2020 were severely wet with anomalies greater than 1.5. These conditions favored agricultural activities and also increased the occurrence of landslides, soil erosions and flooding in the lower parts of the Sub County. The SON season of 1993,1997,2003,2005, 2009 and 2016 were moderately dry. (dry anomalies: -1 to -1.5).

The SON rainfall trend showed slight increase at the rate of 0.04mm per year. The P-Value= 0.013<0.05), implying that the increment was statistically significant.

The results from the Mann Kendall test also showed (Table 4.1) a positive significant trend for the MAM rains and for the SON rains.

Table 4. 1 Results from the Mann Kendall test for the rainfall of the study area.

Description	**Kendall's Tau**	**S**	**Variance(S)**	**P-value**	**Comment**
30-year period	0.131	57	3141.667	0.318	Positive insignificant trend
MAM rains	0.305	132	3138.667	0.019	Positive significant trend
SON rains	0.299	130	3140.667	0.021	Positive significant trend

4.2 Indigenous Knowledge and practices

4.2.1 Awareness about local indicators for predicting destructive rains

To respond to rainfall variability, first it is important to be aware of how this manifests. A number of Indigenous Knowledge Systems have been used to predict the occurrence of certain hazards such as destructive rains, landslides, river flooding and drought (Figure.9). This knowledge is normally with the elderly, and is region and culture specific.

Generally, when the respondents were probed about climatic changes, 76% believed that this change was evident and 24% did not believe it. This difference in perception could be explained by differences in age bracket among the respondents where the youth may not have history of area climate changes. Also level of awareness could have left some respondents especially those with low levels of education unaware of climate changes as opposed to the educated respondents. Respondents further revealed that historical rains received in the area never used to be destructive; cases of landslides were unheard of. Also, the rainfall patterns used to be predictable unlike today where variations in the amounts and timing of the rains received in the areas are common. Different communities and places have been impacted by climate change differently and so also their perceptions towards climate change tend to be different across board. This is normally due to the different exposure, sensitivity and adaptive capacities of such communities. Areas and activities with high exposure, high sensitivity and low adaptive capacity are likely to suffer the consequences of climatic change more. Agriculture, a dominant activity in Bukigai suffers most due to its high level of vulnerability.

When the 76% respondents who admitted that climate changes were evident were probed on indicators of the change, their responses were summarized in Figure 7.

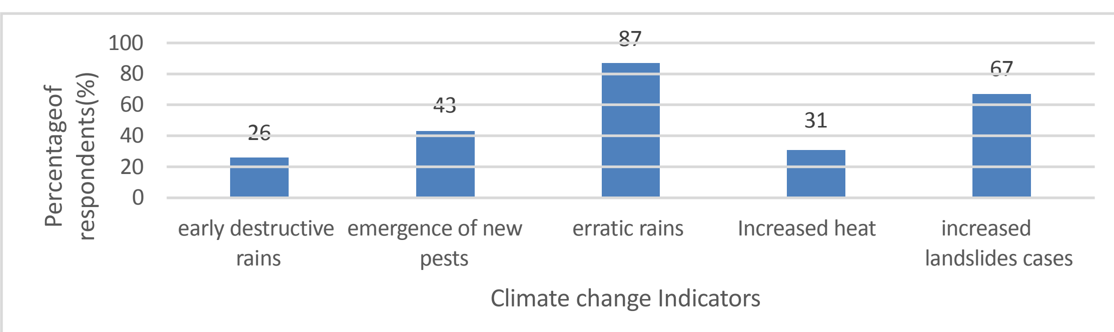


Figure 7: Perceived indicators of climate change in the study area

The results show that a number of observable climate change indicators were observed in the area including early destructive rains (26%), increased heat (31%), emergence of new pests (43%), increased landslide cases (67%), and erratic rains (87%) in the ascending order. Most respondents had observed increase in erratic rains causing flooding and landslides in the recent years compared to the past. Erratic rains wash away top soils, crops and resulting into overall reduced production output registered by the communities at the end of the harvest seasons. The emergence of new pests such army worm, locusts and rodents among others also threaten crop production and food security in the area through damaging leaves and root tubers respectively. Landslides result into crop losses, animals and overall income for the households. The government has disbursed UGX 2.76 billion by 2021 to relocate 276 high-risk households in Bududa as part of mitigation efforts. Overall, the economic cost of landslides in Bududa over between 1991 and 2021 runs into billions of Ugandan shillings when accounting for direct property damage, agricultural losses, infrastructure destruction, emergency response, and government relocation expenditures (IFRC, 2021). This highlights the severe and recurrent economic impact of landslides in the district

Increased heat cases result into increase in malaria cases that translates into more spending on health by the households' exacerbating the overall poverty and poor livelihoods.
The survey further inquired from respondents to know whether they are aware of indicators of some climate change induced hazards. The results are presented in Figure 9.

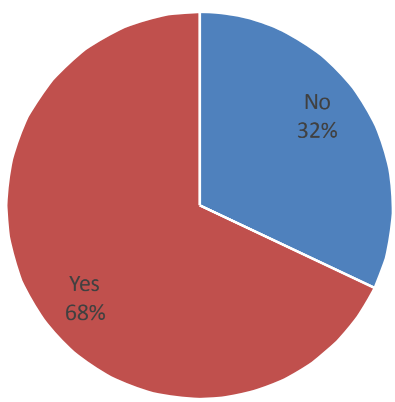
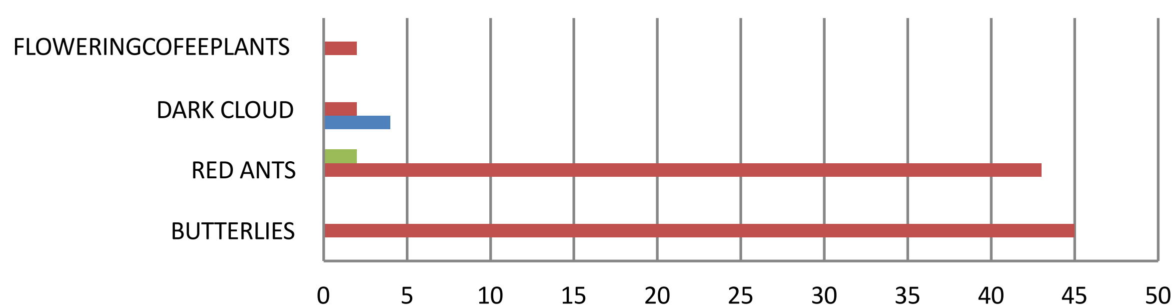


Figure 8: Awareness of local indicators for climate hazards

The results showed that 68% of the respondents were aware of local indicators of climate change and its associated hazards. 32% of the respondents were not aware about any local indicators. This could be attributed to rapid urbanization and generally westernization of weather and climate observations. In addition, generational gaps between the old and young can be cited as another reason, where old people dominate the custodianship of IK. Generally, the area is dominated by a young population whose interest in IK is low.

Communities rely on specific Indigenous Knowledge, including the color of rain clouds and wind patterns, to adapt their cropping methods and livelihood strategies. For example, this knowledge helps them schedule agricultural tasks and implement management practices like building windbreaks and fencing homesteads effectively (Mukhopadhyay, 2010). Local populations are also able to forecast damaging rainfall and storms by observing cloud color, listening to thunder, and assessing drought durations (Gearheard et al., 2010)

Figure 10 shows the indicators of coming of rains, and at times, which are destructive with a likelihood of causing erosion, flooding and landslide cases. The same figure indicates the level of occurrence of destructive rains in case of the named local and area specific indicators.



	BUTTERLIES	RED ANTS	DARK CLOUD	FLOWERINGCOFEEPLANTS
LOW	0	2	0	0
MODERATE	45	43	2	2
HIGH	0	0	4	0

Figure 9: Local indicators of rains

Figure 9 show that in the Bukigai Sub County community, locals interpret the occurrence of butterflies, red ants, dark clouds, and flowering of coffee plants as indicators for coming rains which at times can be destructive. 45% and 43% of the respondents acknowledged local indicators of butterflies red ants to have a moderately high level of occurrence of rains. Only 2% of the respondents pointed out dark clouds and the flowering of coffee as good indicators for beginning of rain season. With dark clouds, 4% of the respondents agreed, there are higher chances of receiving heavy rains, which at times may be destructive rains in the area. These indicators help communities not only plan to vacate landslide prone areas but also secure their property pre-disaster.

Previous studies highlight that traditional Indigenous Knowledge of storm paths and wind patterns enables communities to plan disaster management well in advance by building shelters, windbreaks, walls, and homestead fences accordingly (Kamara, 2005). Changes in birdcalls during mating seasons signal seasonal shifts (Kamara, 2005), while the height of birds' nests near rivers helps predict floods (Oageng, 2012). The population of moths forecasts drought, and the sun's position combined with specific bird calls near rivers signals the start of the rainy season for farming (Oageng, 2012).

In Karamoja, Indigenous Knowledge plays a key role in disaster risk reduction. Migratory bird patterns provide seasonal information; the arrival of specific birds indicates impending rains and a good harvest, whereas abundant rats signal drought in the coming year (Mulenga, 2010). Among the Hehe and Nyakyusa elders of Tanzania, animal behavior, bird and insect movements often predict weather and climate patterns (Chang, Yanda, & Ngana, 2010). Large swarms of red ants appearing between September and November signal imminent rainfall and suggest a favorable rainy season.

In Taung, South Africa, a study on Indigenous Knowledge found that cloud color is used to anticipate hail (Oageng, 2012), while wind direction helps forecast temperature changes (Oageng, 2012). Cloud formations, animal behavior, and changes in certain tree species assist in predicting whether upcoming rains will cause flooding (Dube & Munsaka, 2018). The presence of dark clouds and continuous calls of the Inkanku (a rain-making bird) symbolize heavy rains, which may lead to floods and landslides, as also observed in Bukigai Sub County. Overall, recognizing and integrating local Indigenous Knowledge with scientific approaches would significantly enhance climate change adaptation.

4.2.2 Indigenous practices carried out to adapt to climate change and variability

When respondents of Bukigai Sub County especially farmers were probed on whether they apply indigenous knowledge and practices to adapt to climate change and variability, results obtained are shared in Figure11.

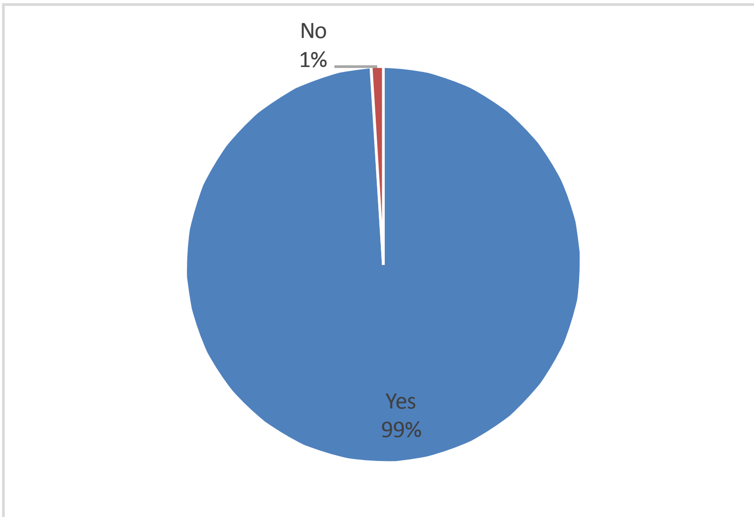


Figure 10: Responses on use of IK strategies for Climate change adaptation

The results showed that 99% of the respondents practiced one or more Indigenous adaptation strategies to cope with the changing climate. Only 1% were not engaged in use of any adaptation strategy. The households' engagement in different indigenous knowledge adaptation strategies varied due to different factors and reasons for instance knowledge about them, and thoughts of inferiority of the strategies.

Previous studies have shown that local communities apply Indigenous Knowledge across various aspects of life, including Disaster Risk Reduction efforts such as disaster prevention and preparedness, food security, agriculture, water conservation, medicinal practices, land use planning, and environmental management (Oageng, 2012). A similar pattern was observed in a survey conducted in Bukigai Subcounty.

With the observable changes and variations in weather and climate, farmers resorted to the use and adoption of simple and probable effective measures to address the climate change in the area. Some of these IK adaptation measures are less effective and at times become a threat in the, long run, causing maladaptation. Climate adaptations prevail best in consideration of societal norms and cultural practices (Adger et al., 2012). For instance, most rural households in Africa use local knowledge to develop coping strategies to shield against risk and uncertainties in the weather (Roncoli, Ingram, & Kirshen, 2002). Figure 12 shows the different IK adaptation practices carried out by the communities in Bukigai subcounty.

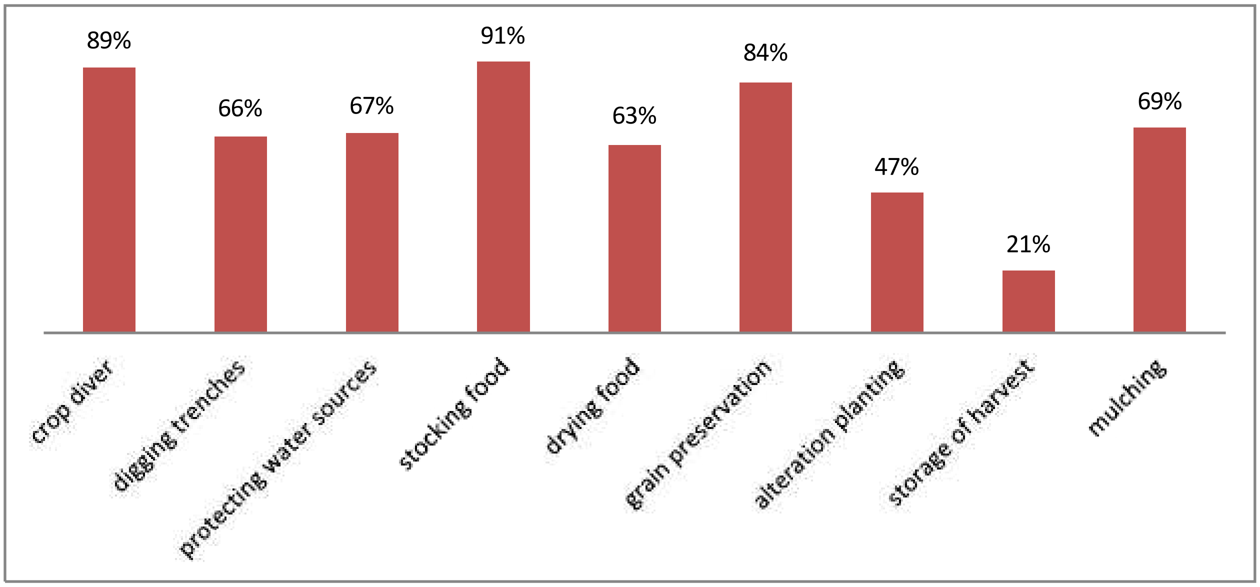


Figure 11: Indigenous adaptation strategies carried out by the study community

The results showed that the respondents practiced food stocking in times of bumper harvest (91%), crop diversifications (89%), and grain preservation (84%). Water conservation techniques to improve water retention such as mulching (69%); protecting water sources (67%); digging trenches before heavy rains (66%); drying food stuffs like beans under the roof during heavy rains (63%); alteration of planting dates (47%); and storage of extra harvest for food supply separately from that destined to the market (21%).

The survey respondents proposed the following adaptation strategies to effectively respond to rainfall variability in Bukigai Sub County (Figure 13).

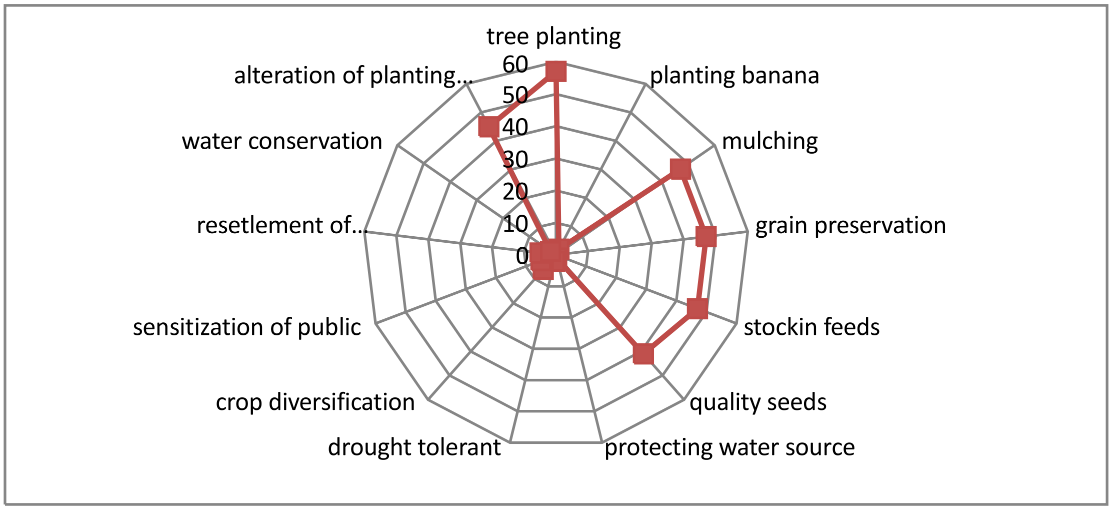


Figure 12: Adaptation options for adoption and promotion proposed by respondents

The results show that a need for investing in tree planting (57%), mulching (47%), grain preservation (47%), stocking of animal feeds (47%), change in planting dates (45%), and provision of quality seeds (41%) dominate. In addition, crop diversification (6%), sensitization of the public (5%), resettlement of landslide victims (2%), drought tolerant crops (2%), banana planting (2%), protecting water sources (1%), and water conservation practices (1%) were also mentioned to have promising potential for promotion in the Bukigai Sub County for improved climate resilience in the area though with low rankings. To achieve community adaptation and build climate resilience, a need to blend both IK and non-IK Adaptation practices is key, and be considered by planners, and policy makers for better and effective climate adaptation.

Table 4. 2 Results of binary logistic regression for indigenous knowledge and adaptation practices carried out to adapt to effects rainfall variability

Variables in the Equation

			Score	df	Sig.
Step 0	Variables	If_yes_crop_diversification	8.173	1	.004
		digging_trenches	1.961	1	.161
		protecting_water_sources	2.051	1	.152
		stocking_food	10.213	1	.001
		mulching	2.248	1	.134
		Drying_foodstuff	1.720	1	.190
		grain_preservation	5.303	1	.021
		Alteration_planting dates	.896	1	.344
		Storage of extra harvest	.269	1	.604
	Overall Statistics		26.616	9	.002

Dependent variable is "Practicing_IK_for_CC"

Table 4.2 shows that crop diversification, stocking of food and grain preservation are significant IK adaptation practices (5% significance level) at addressing effects of rainfall variability.

It is clear from figure 8 that the most adopted indigenous practices were stocking of food followed by crop diversification and grain preservation. Preservation guaranteed what to plant the following season. For the case of crop diversification, farmers diversify crop types as a way of spreading risks on the farm. This practice reduces climate risks as was the case in a study done in Tanzania (Orindi & Eriksen, 2005). The lowest adopted adaptation strategies were storage of harvest and alteration of planting dates respectively. Alteration in planting dates helps to cope with non-consistence when the rains begin and end. In previous studies, due to variation in rain seasons, some farmers planted before the rains, others were planted immediately after rain while others planted after a few days after the first rains in some parts of Tanzania (Liwenga, 2003). These were done on purpose to distribute the risk by ensuring that any rains are utilized for maximum crop production.

In addition, the households were engaged in water conservation as a mechanism to improve the water retention in the soil for good banana growth in some parts of the Sub County, protecting water sources to avoid contamination and make access to clean and safe water for use. Digging trenches helps to move the running water in a guided path, avoiding crop destructions especially during heavy rains.

Indigenous knowledge and practices support local communities in adapting to climate change (MoSTE, 2015). In Nepal, communities have managed natural climate variability and other environmental changes for centuries by innovating and institutionalizing Indigenous Knowledge in the management of natural resources and infrastructure development. This knowledge enhances resilience, mitigates disaster risks to ecosystems and livelihoods, and provides adaptation solutions for climate change vulnerabilities and impacts. It enables communities and their institutions to prepare, develop, and implement effective adaptation strategies and actions (MoSTE, 2015). Indigenous and local people, living in close connection with natural resources, are able to quickly perceive environmental changes and adjust their activities accordingly (MoSTE, 2015). Figure 13 illustrates respondents' views on the impact of Indigenous Knowledge and practices on household production in Bukigai Sub-county.

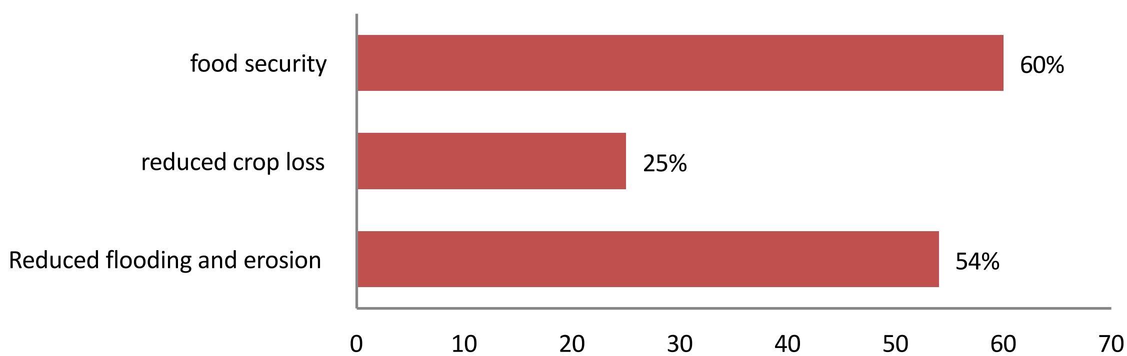


Figure 13: Impact of IK strategies on community resilience to effects of rainfall variability

The results show that indigenous adaptation strategies result into improved food security (60%), reduced flooding and erosion (54%), and reduced crop loss (25%). The greatest impact of IK on output production has been observed in the food security sector. This is a good indicator that if the IK practices are well implemented, they could help to boost community resilience in the area amidst climate change. Some practices such as digging trenches would help to reduce flooding and erosion of the top fertile soils for crop growth and overall output production. For local communities, adaptation is the first priority. And to successfully adapt, strategies need to address the local context and IK can be strategically weaved into those efforts (Nakashima, 2012).

Resilience building efforts could be enhanced if the response strategies promote flexibility and diversity as well as integration of indigenous Knowledge.

Much as most native communities in many countries across the globe are using IK, it continues to face a number of challenges, which limit its capacity to effectively score in areas such as climate change adaptation. Previously, IK has been termed as undependable due to lack of clarity of what constitutes indigenous knowledge which limits its applicability. Policy makers are just beginning to appreciate the role indigenous knowledge systems in the management of challenges of climate change and for disaster risk reduction. The results in Figure 14 illustrate the challenges the communities of Bukigai Sub County reported that are limiting the use and uptake of IK systems and practices for climate adaptation.

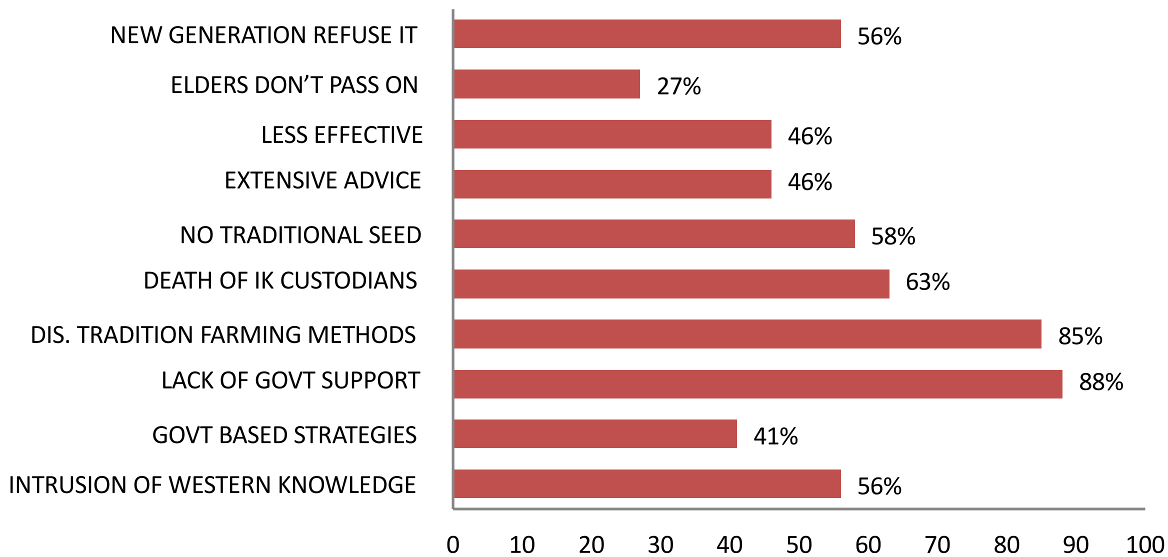


Figure 14: Challenges of applying IK for climate adaptation in Bukigai Sub County

The results show that lack of government support (88%), disappearance of traditional farming system (85%), death of IK Custodians (63%), disappearance of traditional seeds (58%), new generation refusing their use (56%), Intrusion of western knowledge (56%), less effectiveness (46%), lack of extension advice (46%). Inception of government-based adaptation strategies (41%); and elders not passing them on; are all challenges facing the application of Indigenous Knowledge strategies for climate adaptation in the communities of Bukigai Sub County, Bududa district.

Although people possess Indigenous Knowledge and use it every day, they are not aware that it is Indigenous Knowledge, and that they are using it for the purposes of adaptation (Oageng, 2012).

Older people in the community mainly possessed indigenous Knowledge and this has implications for it possibly becoming extinct when they pass on.

4.3 The influence of selected socioeconomic factors on adoption of Indigenous Knowledge and practices

To fully understand the influence of socio-economic factors on Indigenous Knowledge and practices, these factors were analyzed first in Table 2.

Demographic and socio-economic characteristics were important to consider in this study because some of the factors actually influence what IK adaptation practices farmers use to cope with climate change and build their resilience. The demographic and socio-economic characteristics of the respondents such as age, level of education, household size, annual income estimate, and economic activities of households in Bukigai sub-county are found in summarized frequency distribution Table2. For continuous variables such as income, age, and household size, they were summarized with measures of central tendency such as mean and standard deviation.

Table 1: Summary statistics for the demographic and socioeconomic variables

Characteristic of respondents		**Frequency**	**Percent (%)**
Sex	Male	55	55
	Female	45	45
Education level	Tertiary	2	2
	Secondary	19	19
	Primary	64	64
	Non formal Education	15	15
Economic activities	Crop growing, Yes	65	65
	No	35	35
	Cattle keeping, Yes	16	16
	No	84	84
	Trade, Yes	9	9
	No	91	91

According to this study, 55% of the respondents were male and 45% were female. Both men and women were equally engaged to get the views of the different gender on the use of IK to boost the communities' adaptive capacity in Bukigai Sub County.

The results illustrate that only 2% of the respondents in the study area had attained tertiary education, 19% had attained secondary education, 64% had attained primary education and 15%

had non-formal education. Respondents' education levels were required to find out if there are any relationships with the use of IK as a measure to increase the Bukigai Community adaptive capacity. Education allows farmers access appropriate information and encourages the use of either IK or non-IK practices for climate action.

Majority of the respondents (65%) were engaged in crop growing, cattle keeping (16%) and trade (9%) as a source of their livelihoods (Table 2). The respondents in the study were majorly small scale farmers who grew crops mainly for consumption and surplus sold. There were issues of land rights, access, and control especially by women as dictated by culture in the study area.

Table 2: Descriptive statistics for the demographic and socio-economic continuous variables

Variable	**Obs**	**Mean**	**SD**	**Min**	**Max**
Age (years)	100	48	14	23	83
Household Number	100	7	2	2	15
Estimate Annual income (UGX)	100	3,851,000	5,117,992	300,000	21,000,000

From table 3, the estimated mean age of respondents was 48, with the youngest being 23yrs and the oldest 83 years. The age standard deviation of the respondents was 14 years (Table 4.2). Age could be an important factor in influencing the use of IK Adaptation practices by farmers in Bukigai Sub County, therefore this needs to be explored. Age may reflect the importance of exposure to IK over time by the communities in Bukigai. It could be argued that older farmers had considerable knowledge and skill in the use of Indigenous Knowledge and adaptation practices to enhance their adaptive capacity over time. Previous studies illustrate that age increases the probability of conducting adaptive measures such as tree planting (Deressa *et al*., 2009). In the researcher's observation, the average age being 48, age could be playing a key role in adoption of indigenous adaptation practices.

The mean household size of the respondents was 7. Also, the smallest family had 2 members and the biggest had 15 members (Table 3). Household sizes would in one way or the other also influence the use of IK by farmers as an alternative or a means to enhance the household adaptive capacity. Previous studies show that household sizes influenced the adoption of agricultural interventions and affected the household's adoption rate (Croppenstedt, Demeke, & Meschi, 2003).

The estimated mean annual household income of the respondents was UGX 3,851,000, with the UGX 300,000 being the least income earned and UGX 21,000,000 being the highest earned from the sample respondents in a year (Table 3). Studying household incomes is important in this study on IK and Non-IK adaptation practices. This could influence the uptake of certain IK and Non-IK feasible adaptation options for climate resilience building of the Bukigai community. Previous studies show that income contributes positively to the adoption of agricultural technologies

(Knowler & Bradshaw, 2007). People with low incomes may tend to concentrate on the cheapest IK adaptation strategies than the Non-IK Strategies for increased climate resilience.

Like earlier mentioned above, IK is majorly a preserve of the older generation, we have seen the new generation having less interest in the use of IK, amongst other challenges. This therefore makes it important to assess the impact of various factors that could be influencing the use of IK in Bukigai Sub County. The different demographic and socio-economic characteristics have to be examined to have an insight on the probable determinants for the use of IK in Bukigai (Table 4).

Table 3: Influence of socio-economic factors on the use of IK practices for climate adaptation

Practicing IK for Adaptation	dF/dx	Std. Err	z	P>z	[95% C.I.	]
Age	-0.1571	0.0349	-0.45	0.653	-0.8412	0.5271
Education	-0.0138	0.6431	-0.02	0.983	-1.2742	1.2467
Household Income	1.21e-7	4.05e-7	0.30	0.766	-6.74e-7	9.15e-7
Observed Probability	P	0.0625				
Predicted Prob. Value	P	0.0685	(at x-bar)			
Log likelihood = -4.6721 **LR chi2 (3)** = 0.65 **Prob>chi2** = 0.088 **Pseudo R^2** = 0.0625						

The Probit tests to find the casual relationship between the use of IK as adaptation practice and selected socioeconomic factors such as age, household income and education. The results showed that none of the tested factors was statistically significant in influencing the use of IK for adaptation.

All the P-Values are greater than the significance level at 5% (0.005). For age (P-Value= 0.653), education level (P-Value= 0.983); and income (P-Value= 0.766).

In conclusion, the probit test results gave a pseudo R^2 of 6%. This means that the selected socioeconomic only account for 6% in adoption of IK and practices. The chi-square result of 0.65 shows that the model is not statistically significant at 5%. The chi-square result implies that none of the factors studied influence the communities' engagement in the use of IK for adaptation.

4.4 Discussion of results

The findings presented in the study regarding climate variability perception, Indigenous adaptation strategies, and the influence of socio-economic factors is consistent with previous studies. The results highlighted significant trends of both seasonal and annual rainfall variability, underscoring the importance of understanding local climate dynamics in adaptation planning as pointed out by Mugambiwa & Tirivangasi, (2018). With 76% of respondents acknowledging climate variability, there is a widespread recognition of environmental changes within the community, which is essential for fostering adaptive capacity and resilience. However, the study also found that 24% of respondents did not believe in climate variability, indicating a potential need for targeted awareness-raising efforts to address gaps in understanding and perception regarding environmental issues. Evident rainfall variability, significant trends of both seasonal and annual rainfall variability point to likelihood of weather extremes such as floods and droughts. These require building of household resilience through livelihood programmes, capacity development of locals to create climate change awareness and development of EWS among other proactive interventions.

Moreover, the study revealed a high level of engagement in indigenous knowledge and adaptation practices among the surveyed population, with 99% of respondents admitting to practicing one or more indigenous techniques to cope with changing climate conditions. These findings align with existing literature emphasizing the importance of Indigenous Knowledge and practices in climate adaptation and resilience-building efforts (Berkes, 2018). Key strategies such as food stocking, crop diversification, and grain preservation were particularly prevalent, reflecting the community's reliance on traditional agricultural practices to mitigate the impacts of climate variability on food security and livelihoods.

However, despite the widespread adoption of Indigenous knowledge and adaptation practices, the study's probit tests found that none of the tested socio-economic factors (age, income, and education level) demonstrated a statistically significant influence on the use of Indigenous Knowledge for adaptation purposes. This finding aligns well with findings of Charnley & Durham (2010) which asserts that factors beyond individual demographics may play a more significant role in shaping adaptive behavior. The low pseudo R^2 value of 6% further indicates that the socioeconomic variables tested could only explain a small portion of the variations in respondents' engagement with Indigenous Knowledge, highlighting the complex and multifaceted nature of climate adaptation processes and the need to explore other factors such as cultural and institutional influences that may influence the adaptation option.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

From the results, it can be concluded that the rainfall trends of Bukigai sub-county showed a positive slight increment at annual basis and at seasonal basis for the cropping seasons of MAM and SON over the study period. However, the rains showed great anomalies at annual and seasonal basis depicted by variations below and above the long term mean. Variations above the mean increase the risk for floods and ultimately landslides. This has potential to cause soil erosion, crop failure and loss of livelihoods among other effects. Conversely rainfall fluctuations annually and at seasonal basis below the long term mean meant that the study area experienced dry spells and droughts that varied in intensity from mild, moderate to severe. These conditions threatened food security, water supply and agriculture majorly a sole source of livelihood for the study area.

Furthermore, this study has revealed that communities in Bukigai Sub County still rely on some indigenous knowledge and practices like looking at colour of clouds to predict rain, look at appearance/disappearance of animals and some insects to foretell approach of rains/seasons as well as dominantly practicing food stocking, crop diversifications and grain preservation. However, it was noted that the adoption of Indigenous Knowledge (IK) systems and practices was increasingly becoming less in the Sub County due to a number of hindrances, among which are the demise of the old custodians of IK, lack of interest by the young generation, intrusion of western knowledge amongst others as earlier discussed.

Additionally, Probit tests revealed that no socio-economic factor among Age, Education and Household Income was statistically significant at 5% significance level in influencing the use of IK for adaptation to rainfall variability. The test further revealed that Age, Education and Household Income could only account for 6% adoption of indigenous knowledge and practices which points other influencing factors not studied under this research.

Generally, the findings of this study underscored the importance of Indigenous Knowledge and practices in facilitating adaptation to climate variability in Uganda. While there is a widespread recognition of climate change impacts and a high level of engagement in Indigenous knowledge and adaptation practices, socio-economic factors alone do not significantly influence the adoption of Indigenous Knowledge. Future research should explore additional contextual factors and socio-cultural dynamics that may shape adaptive behavior, in order to inform more effective and targeted interventions for building climate resilience in vulnerable communities.

5.2 RECOMMENDATIONS

This study makes several recommendations to enhance the understanding of Indigenous adaptation strategies and their relationship with socio-economic factors in the context of rainfall variability in Bukigai Sub County.

This study recommends that a robust and long-term rainfall monitoring system should be enhanced and maintained by the authority in charge of meteorology and climate change in the country. Civil society, media and development partners could as well also join this campaign to sensitize, create awareness about climate change as well as increase weather station network for support EWS. Continuous monitoring of rainfall patterns will provide valuable insights into patterns, enabling researchers to better understand the dynamics of climate variability in the study area which could further guide on mitigation and adaptation planning.

To fulfill the objective of examining existing Indigenous Knowledge and practices used to address the effects of rainfall variability, it is crucial to engage with local communities and authorities to document traditional coping strategies and adaptation techniques. Documenting helps to preserve Indigenous Knowledge and therefore cultural heritage

It is further recommended to prioritize capacity building initiatives and knowledge exchange activities to enhance the resilience of communities in Bukigai Sub-County. This could involve organizing training workshops, farmer field schools, and knowledge-sharing platforms to disseminate information about effective Indigenous adaptation strategies and build local capacities for climate change resilience. Additionally, fostering collaboration and partnerships between researchers, government agencies, NGOs, and local communities can facilitate the co-creation and implementation of contextually appropriate adaptation measures.

Finally, future research should explore additional contextual factors and socio-cultural dynamics that may shape adaptive behavior, in order to inform more effective and targeted interventions for building climate resilience in vulnerable communities.

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APPENDICES

1. Survey Questionnaire

Dear Sir/Madam,

I am **Martin Ojok**, a student at Busitema University carrying out a research study titled "Assessing the role of indigenous knowledge and practices for adaptation to effects of rainfall variability in Uganda*; a case of Bududa district."* 'I am kindly asking for your participation. Data collected shall be treated with confidentiality and is purely for academic accomplishments. I thank you.

Questionnaire Administrator:……………………………

Respondent No………… Date:………………………...

SECTION A: Demographic and socio-economic characteristics

1. Location

District …………… Sub-county…………………… Parish……………
Village ………………

2. Sex of the respondent, please tick appropriately

1) Male 2) Female

3. What is your age?

………………………………………………………………………………

4. What is your highest level of education?

1) Tertiary 2) Secondary 3) Primary 4) No formal education

5. How many people are you in the household? ....

6. Household estimated income/year……………………………………………………….

7. Which economic activities do you do?

1) Crop farming 2) Cattle rearing 3) trade 4) others (specify)………………...

SECTION B: Community Climate Change Analysis

8. Do you believe there is climate change in Bukigai Sub County? Yes/No
9. What are the perceived climate change indicators in your community?

SECTION C: Indigenous Knowledge and non-IK Adaptation options used by farmers

10. Are you aware of any local indicators to predict destructive rains (likely to cause landslides and floods) in your area? Yes/No

11. If yes, name five of them and give their estimated level that event actually happens?

Indicator	Level the event occurs (1= High, 2= Moderate 3=low)

12. Are you practicing any indigenous adaptation strategy against climate change? Yes/No
13. If yes, what indigenous practices do you carry out to adapt to the climate and climatic change related challenges in your community? (Tick appropriately)

a) Crop diversification
b) Digging and construction of trenches before heavy rain
c) Protecting of existing water sources
d) Stocking of foods in times of bumper harvests
e) Water conservation techniques to improve water retention such as mulching
f) Drying food stuffs like beans under the roof during heavy rains- for food security
g) Grain preservation
h) Alteration of planting dates
i) Storage of extra harvest for food supply separately from that destined to the market

14 Of what impacts are the above mentioned indigenous adaptation strategies to climate change in terms of sustained production output?

……
……

15. Name any non-indigenous adaptation strategies (government based) being carried out in your community by any stakeholders like NGOs, government, district, etc?

……………………………………………………………………………………………..
………………………………………………………………………………………………..
………………………………………………………………………………………………..

16 What are the challenges of applying indigenous knowledge and practices on climate change adaptation?

a) Intrusion of western knowledge
b) Inception of government based adaptation strategies
c) Lack of government support
d) Disappearance of traditional farming system
e) Death of IK custodians
f) Disappearance of traditional seeds
g) Extension advice
h) Less effective
i) Elders do not pass them on
j) New generation refuse their use

SECTION D: RECOMMENDATIONS

18. What are the adaptation options (IK and Non-IK) that are promising / feasible and can be recommended for promotion in the Bukigai Sub County?

…………………………………………………………………………………………………..
…………………………………………………………………………………………………..

2. KEY INFORMANT GUIDE

The following questions guided the key informant interviews

1. What is the level of climate change awareness in Bukigai Sub County?

2. What could be the local indicators of climate change and variability in the region?
3. How do locals respond to climate shocks?
4. Which indigenous response strategies applied?
5. How can response be made more effective?

3. FIELD SURVEY OBSERVATION CHECKLIST

Indigenous knowledge indicators and Climate change

1) What are the indicators of a looming prolonged drought in the area?
2) What are the local indicators of rainfall seasonal variations and changes in the area?

Indigenous knowledge and non-indigenous knowledge adaptation practices

3) Please explain indigenous and non- IK adaptation practices used by local communities to withstand the changing climate (changes in precipitation and drought, winds, etc.)

Relevance and Challenges, Recommendations for climate change adaptation

4. Do you think indigenous knowledge practices are helpful to adapt to climate change? If yes, how relevant are they?

5. What are the underlying challenges of using indigenous knowledge practices on climate change adaptation?

6. What are the adaptation options (IK and Non-IK) that are feasible and recommendable for promotion in the study area?

Thank you