

**ASSESSMENT OF ADAPTATION STRATEGIES TO MITIGATE IMPACTS OF  
CHANGING RAINFALL PATTERNS ON CROP PRODUCTION IN PAYA  
SUBCOUNTY, TORORO DISTRICT**

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**A RESEARCH REPORT SUBMITTED IN PARTIAL FULFILMENT OF  
THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF  
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**SEPTEMBER, 2024**

## DECLARATION

I, Adirubo John do hereby declare that this research report is my original work and has not been presented for award of bachelor's degree or diploma in any other institution

Sign .....  .....

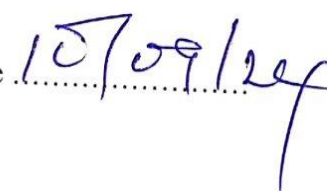
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### APPROVAL

This is to certify that the project report entitled “adaptation strategies to mitigate the impacts of changing rainfall patterns on crop production in Paya Sub-county, Tororo district” submitted in partial fulfillment of the requirement for the award of the degree of bachelor of Science Education of Busitema university is an authentic record of bona fide report carried out by Adirubo John (BU/UP/2021/1514) under my guidance and supervision. No part of this report has been submitted for any other degree or diploma.

Sign  .....

Mr. Dramadri Gerald Afayo

Date  .....

## **DEDICATION**

I dedicate this piece of work to my beloved parents Mr. Ekumadrini KasianoDratro and Mrs. Yesko Lilly and the entire family.

## **ACKNOWLEDGEMENT**

I would like to thank the Almighty God for the Grace throughout the period I have spent in Busitema University carrying out this study. The various activities would not have been possible without the help from various individuals who have extended their assistance financially, physically and through guidance.

A Special thanks to my supervisor; Mr. Dramadri Gerald Afayo for the valuable guidance, useful corrections and comments that enabled me successfully complete the study. Furthermore, I would like to thank all the lecturers in the agriculture department; my family members, for their tireless support; friends including Akuma Jamal, EyotaruEverlyn, Donia Evaline, Opio Godfrey Moi and Eyotre Vincent and all my course mates for the nice and supportive stay during the course at Busitema University.

## ABSTRACT

Climate change has greatly affected agricultural practices in many regions across the world, with the farmers in developing regions for instance Paya in Tororo district of Uganda, particularly much likely to be affected by these changes. This study documentation therefore employed the Sustainable Livelihoods Framework (SLF) to find out farmers' thoughts and perceptions on the changes in precipitation, their effects and strategies employed by farmers to cope up with the changing rainfall patterns. A sample of 64 farmers from Paya was selected to gain an insight into the demographic profiles, perceptions of rainfall variability, observed effects on crop production, adaptation strategies employed to cope up, perceived effectiveness of these strategies and challenges. The results show a varied age distribution among farmers, with a majority of them having primary and secondary education levels. Most of the farmers have 5-15 years of experience in farming. A high proportion of farmers reported great alterations in rainfall patterns, including irregular distribution, changes in intensity, varied frequency of rains and change in the duration culminating into reduced crop yields, drought stress and soil erosion. According to the study, farmers have also implemented a number of techniques to mitigate the negative effects including modifying planting schedules, using drought resistant varieties and collecting rainwater. Nevertheless, obstacles including restricted availability of climate data and exorbitant resource costs significantly impede the successful execution of these approaches. This study portrays the vulnerability of farmers in Paya to changing rainfall patterns and the different adaptation strategies they employ, projecting that the effective adaptation is mostly hindered by inadequate information, infrastructure and financial constraints. Therefore, increased investment in region-specific research, provision of climate-resilient seeds, infrastructure development and improved extension services could enhance adaptive capacity and resilience in agricultural practices of crop production.

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## **LIST OF ABBREVIATIONS AND ACCRONYMS**

CMIP	Coupled Module Inter-comparison Project
DFID	Department for International Development
FAO	Food and Agricultural Organization
IK	Indigenous Knowledge
MAM	March – April - May
OND	October – November - December
SLF	Sustainable Livelihoods Framework
SST	Sea Surface Temperature
UBOS	Uganda National Bureau of Statistics

# CHAPTER ONE

## 1. INTRODUCTION

### 1.1. Study Background

Climate change is a global phenomenon which has severe effects on various aspects of human life including agriculture, water resources and ecosystems. One of the most noted effects of climate change is the alteration of rainfall patterns which has had significant effects for communities that heavily rely on rain-fed agriculture (Cheryl D, 2002). Rainfall pattern as the amount and distribution of precipitation over a given period of time (typically a year or season) in a particular region, also referred to as patterns of dry and wet years in an area impacts agriculture in several ways (Bates et al. 2008)

The Changes in rainfall pattern is a consequence of global warming and has influenced the world's agriculture, especially third world agriculture to be dependent on the seasonal rainfall pattern with which a growing number of people worldwide experience food insecurity as a result of recent unpredictable changes in the pattern of rainfall thus reducing agricultural productivity (Zhao et al. 2017)

Therefore, worldwide rain-fed agriculture is scheduled according to the natural pattern of rainfall. The average yearly rainfall is taken into account while designing irrigation networks, water supply systems and water storage facilities (Nelson et al. 2009). If it rains a lot on a continuous basis for a longer time, there is possibility of flood and subsequent disaster to the agriculture field. No rainfall or little rainfall for a longer period in the inhabited area could lead to drought and famine.

Shifts in rainfall patterns have also been experienced across regions of Africa with distinct variability in the intensity of these changes across regions but overall, they are characterized by increased variability, intensity and frequency of extreme weather events such as droughts and floods (Choi et al., 2022).

Looking into Africa in historical perspective, the continent has been characterized by distinct rainfall seasons, with the north and south experiencing winter rainfall and the equatorial

region experiencing bimodal rainfall but climate change is disrupting these patterns, leading to shifts in the timing and distribution of rainfall (Choi et al., 2022).

Some studies carried out indicate that there has been a general increase in the intensity of rainfall events in many parts of Africa, leading to an increased risk of flooding. This is particularly evident in regions such as Eastern Africa, where extreme rainfall events have become more frequent and intense (Ngoma et al., 2022).

Conversely, some parts of Africa are experiencing decreased rainfall, leading to more frequent and severe droughts. These changes have serious implications for agriculture, water resources and food security in the region (Niang et al., 2014).

Across the Eastern Africa, Uganda in particular has a tropical climate with two rainy seasons per year: from March to May (long rains) and from September to December (short rains) (Ngoma et al., 2022) but there are seemingly changes in climate altering these patterns, leading to changes in the timing and intensity of rainfall across the country.

Studies indicate that Uganda is experiencing changes in rainfall patterns, with some regions experiencing increased rainfall intensity and frequency, while others are experiencing decreased rainfall (Ngoma et al., 2022). Climate models project that Uganda will experience no significant change in annual rainfall between the present and the mid-21st century. However, there are indications of an increase in precipitation during the traditionally dry season of December, January and February (Xscience, 2020). This change in rainfall patterns could have both positive and negative impacts on agriculture, depending on the region and the crops grown

In the context of Uganda, like many other African countries, is already experiencing the impacts of changing rainfall patterns, with adverse effects on crop production and food security. (Nkoya et al, 2016) In Tororo district located in eastern Uganda, agriculture is the main economic activity providing source of livelihood for a large proportion of the population (UBOS, 2016). The district is known for its high agricultural potential, but changing rainfall patterns are posing challenges to farmers affecting crop growth and yield (Munang et al, 2013) inclusive of PayaSub County.

The majority of the population in this area depends on rain-fed agriculture for their subsistence. However, in recent years, the community has experienced noticeable changes in rainfall patterns, including irregular and unpredictable rainfall distribution, prolonged dry spells and increased frequency of extreme weather events such as floods along rivers banks and droughts (Smith M, 2011). These changes have had adverse effects on crop production, leading to reduced yields and food shortages.

The changing rainfall patterns due to climate change negatively impact crop productivity by causing excessive heat, drought and altered growing periods, ultimately affecting food security and varying by region and crop type.

### **1.2. Statement of the Problem**

The community of Paya Sub County located in Tororo district of Uganda heavily relies on rain-fed agriculture as the primary source off their livelihood for its residents. However, the region has experienced notable changes in rainfall patterns which have led to increased uncertainty in planting and harvesting seasons, extremes of rainfall and lengthened dryness periods negatively affecting crop yields, food security and jeopardizing the livelihoods of farmers in the region.

Despite the importance of agriculture for livelihoods and economic development in the area, there is limited understanding of how to cope up with the changes and the adaptation strategies to be employed by farmers to mitigate the impacts of changing rainfall patterns. Therefore a critical need exists to assess the effectiveness of these adaptation strategies and to identify challenges faced by farmers in implementing and sustaining these strategies.

Besides the existing adaptation strategies developed based on traditional knowledge and practices, their effectiveness in the face of current and future challenges of changing rainfall patterns is uncertain. Furthermore, there is a gap in the literature regarding the perceived effectiveness of adaptation strategies in reducing the negative impacts of changing rainfall patterns on crop production in Paya. This study seeks to address this gap by examining the adaptation strategies employed by farmers, assessing their perceived effectiveness and identifying areas for improvement to enhance resilience in agricultural practices.

### **1.3. Aim/Main Objective**

The main objective of this study is to assess the adaptation strategies implemented by the community in Paya to cope with changing rainfall patterns.

### **1.4. Specific Objectives**

In particular, the study seeks;

- i. To find out the changes in rainfall pattern farmers have observed and impacts of changing rainfall patterns on crop growth and yield in Paya.
- ii. To identify the strategies employed by farmers in Paya, Tororo District to mitigate the impacts of changing rainfall patterns on crops.
- iii. To seek farmers' perception on effectiveness of these adaptation strategies in reducing the negative impacts of changing rainfall patterns on crops.
- iv. To explore the challenges farmers in Paya face in implementing and sustaining the strategies in response to changing rainfall patterns.
- v. To identify potential areas for improvement and recommend suitable adaptation strategies to enhance resilience in agricultural practices.

### **1.5. Research Questions:**

- i. What climate variability have farmers observed in the past years in consideration of precipitation/ rainfall?
- ii. What have been the main impacts of changing rainfall patterns on the crops growth and yield in Paya?
- iii. How do farmers in Paya perceive and adapt to the changing rainfall patterns in their agricultural practices?
- iv. Which challenges and barriers are being faced by farmers in implementing and sustaining adaptation strategies in response to changing rainfall patterns?
- v. What are the best practices and recommendations for improving the adaptation and enhancing the resilience to changes in rainfall patterns in Paya?

## **1.6. Research hypotheses**

### **Main hypothesis**

Null hypotheses; there is no significant relationship between the adaptation strategies employed by farmers and their perceived effectiveness in mitigating the impacts of changing rainfall patterns on crop production in Paya.

Alternative hypotheses; there is a significant relationship between the adaptation strategies employed by farmers in Paya and their perceived effectiveness in mitigating the impacts of changing rainfall patterns on crops.

### **Specific hypothesis**

Hypothesis one; there is a significant difference in crop growth and yield between periods of normal rains and periods of changing rainfall patterns in Paya

Hypotheses two; farmers in Paya employ a variety of adaptation strategies to mitigate the impacts of changing rainfall patterns on crop productivity

Hypotheses three; there is a positive correlation between the adoption of adaptation strategies and the perceived effectiveness of these strategies in reducing the negative impacts of changing rainfall patterns on crops in Paya.

Hypotheses four; farmers in Paya face challenges such as limited access to modern agricultural inputs, financial constraints and inadequate knowledge of effective adaptation practices in implementing and sustaining adaptation strategies in response to changing rainfall patterns.

Hypotheses five; there is a need to identify and recommend suitable adaptation strategies, such as strengthening support mechanisms (e.g., extension services, community-based initiatives), promoting climate-smart agriculture and enhancing access to credit and financial assistance, to enhance resilience in agricultural practices in Paya.

### **1.7. Justification:**

Assessing the adaptation strategies to changing rainfall patterns in Paya, Tororo District was of utmost importance as the district is highly dependent on rain-fed agriculture, making it vulnerable to the impacts of changing rainfall patterns thus understanding the current and past rainfall patterns provides valuable insights into the climate trends and their potential impacts on agricultural productivity.

Secondly, the identification and evaluation of the effectiveness of the existing adaptation strategies helps in determining the best options for continued agriculture and identifying potential gaps. This information can be used to develop targeted interventions and policies to enhance the resilience of the community to changing rainfall patterns.

### **1.8. Scope of the research**

The study was conducted in Paya sub county, Tororo District, Uganda. This area was chosen due to its susceptibility to changing rainfall patterns and its reliance on agriculture as a primary livelihood source. The study involved farmers who were engaged in crop production and the findings of this research were not generalized to other regions, contexts, or crops.

The research focused on the changing rainfall patterns in Paya Sub County, assessing the strategies employed by the population in the study area and their effectiveness, challenges in implementing these strategies and recommendations. The study did not aim to explore the causes and mechanisms of changing rainfall patterns, nor the impacts on other aspects of agriculture such as livestock.

The study considered data spanning the past decades to assess changes in rainfall patterns and their impacts on crop production. Data collection was conducted and the research process was completed in July, 2024

The research relied on the self-reported data from the farmers, which may have been subjected to recall bias, social desirability bias, or measurement error. The research faced some practical challenges/limitations such as time constraints, budget limitations, ethical issues and logistical difficulties in conducting the fieldwork, data collection and analysis.

### **1.9. Conceptual Framework**

The conceptual framework for this research was based on the Sustainable Livelihoods Framework (SLF) which was developed by the Department for International Development (DFID). The SLF framework provided a holistic approach in understanding livelihoods and employed strategies by individuals and households to cope with various shocks and stresses including those related to climate change.

The components of this framework includes livelihood assets comprising natural capital, human capital, physical capital and social capital, the strategies including diversification, enhancement and transformation, and the outcomes such as sustainable livelihoods, enhanced resilience and improved food security.

## **CHAPTER TWO:**

### **2. LITERATURE REVIEW**

#### **2.1. Introduction,**

Climate change has become a global issue having significant impacts on agriculture and various other aspects of human life, water resources and ecosystems with its manifestation in various ways. Most importantly, one of the most observed effects of climate change is the alteration of rainfall patterns, which can have severe consequences on agriculture for those communities that depend on the natural rainfall for farming which is usually seasonal (Hussain et al, 2021).

The shifting rainfall patterns worldwide have been linked towards incidences of increasing temperatures which accelerate evaporation resulting in high levels of moisture in the atmosphere which can bring intensified rainfall events including frequent and severe storms, floods and even hurricanes but some regions may experience reduced rainfall and prolonged droughts due to changes in atmospheric circulation patterns caused by such changes much possibly resulting into global warming. Along with the increase in temperature, there are changes in large-scale hydrological cycle elements, such as an increase in atmospheric water vapor, shifting precipitation patterns, changes in precipitation intensity and extreme events and variations in soil moisture content and runoff (Huhoeet al., 2017)

#### **2.2. Notable changes in rainfall pattern and their impacts on crop productivity**

From the past years, there have been notable shifts in rainfall patterns and amounts for example, between 30°N and 85°N latitude, precipitation grew overall between 1900 and the 1950s and notably between 10°N and 30°N; however, from 1970 until the present, precipitation has decreased (Easterling et al. 2017). This can be projected to still take place in the present.

Global precipitation patterns are being moved in new directions by climate change, with wet areas getting wetter, dry areas getting drier and storm tracks moving toward the poles (Trewin, 2014). Climate models predict that the average precipitation will increase in a warmer world, but the change will vary across regions and seasons (Pendergrass et al, 2017).

Climate models provided projections of future precipitation changes, broken down by season which do indicate the direction of change for each season in certain regions, indicating a level of confidence in the predicted trends and there is a disparity in rainfall trends and patterns among different regions, which can be attributed to various factors including geographical location, topography and human activities (Babaouismail, 2022).

According to Babaouismail (2022), the average annual precipitation over the United States has increased by about 5% from the year 1900 however; the change is not uniform across the country up to the present. He stated that, since 1991, the Northeast, Midwest and southern Great Plains have seen the most significant increases in precipitation while the Southeast and Southwest have experienced both an increase and a decrease at different times.

Rao et al (2015) examined the importance of rainfall variability in agricultural productivity in the Southern Western Ghats of Kerala, India using time series data from 1989 to 2019 and they reported that despite no statistically significant trends in monthly, seasonal and annual rainfall, the yield of many crops like winter paddy and banana were not affected compared to other crops since irrigation was carried out. The study suggested that climate-resilient agriculture in the region should focus on optimizing irrigation and developing sustainable agriculture and water conservation strategies. Another study explored the effect of climate variability on cultivated crops' yield and farm productivity. While the specific details of this study are not provided in the search results, it's likely that the research delves into how different crops respond to changes in climate variables such as rainfall.

Climate change is increasing the threat to human health, food and water security and socio-economic development in Africa, as temperatures and sea levels rise and precipitation patterns change (Ofori et al, 2021). Sub-Saharan Africa is one of the most vulnerable regions to climate change, as well as one of the most understudied (Dickerson et al, 2022). Extreme rainfall events have increased in frequency and intensity over the region during 1960–2017, exhibiting differences in the spread, intensity and frequency. (Choi et al., 2022)

There exist regional differences in rainfall patterns in Africa due to its vast size and varied climates with the Sahel region experiencing a strong inter-annual variability, often associated with droughts and floods and exist even in month-to-month specificity of regional climate

associations across the continent to a high degree which indicates the timing of rainy seasons can vary greatly from one region to another, affecting agricultural crop production cycles and water availability. Over long term from 1901 to 2015, parts of Africa have shown negative trends in annual precipitation, particularly in West Africa along the coastal areas near the Gulf of Guinea with changes in the spread and duration. Otherwise some areas, such as around Lake Victoria, have seen an increase in annual and September–November precipitations. Climate models suggest shifts in climate regions under projected twenty-first-century climate change. For example, the western and eastern Sahel may become distinct regions with different rainfall patterns and teleconnections, especially under high-emissions scenarios. (Muchuru and Nhamo, 2019)

Variability in sub-trends of African precipitation is often linked to changes in Sea Surface Temperature (SST) of the Indian, Atlantic and Pacific Oceans. These oceanic conditions can drive the variability in rainfall patterns, influencing the continent's hydrology and agriculture; meanwhile several dipole regions exist where adjacent areas tend to experience rainfall anomalies of opposite signs which can lead to contrasting conditions within relatively close geographical locations.

A study of East Africa indicated that the region is prone to weather extremes, such as droughts, floods and variable onset and offset of rainfall. A new study based on CMIP6 models projected that annual mean temperature will rise by  $2^{\circ}$  by mid-century and rainfall will increase during the short rains season (November–December), but not during the long rains season (March–May) (Ngoma et al., 2022).

Another study based on CMIP5 models found that population centers in the highlands of Ethiopia will receive more precipitation and more extreme rainfall events during the autumn season. Similarly, heavy rainfall events have been recorded in Kenya during the longest rains season that is from March to May and in the short October to December season. The agro-meteorological impacts of these events have been summed for different regions within the country, indicating how changes in rainfall patterns affect crop growth and productivity.

For the case of Uganda, the climate is largely tropical with two rainy seasons per year, March to May and September to December with some variations in the setting of rains. Parts of the

northern region have been noticed to experienced only one rainy season, March to October and the general country's weather and seasonality are influenced by the Indian Monsoon, Congo air mass, Indian Ocean Dipole and the Inter Tropical Convergence Zone systems, as well as the El Niño-Southern Oscillation phenomena (Ngoma et al., 2022)

Global projections downscaled to Uganda reveal no significant change in annual rainfall between now and the 2015-2045 period, but there are indications of an increase in precipitation during December, January and February, which historically has been the dry season. A recent study based on CMIP6 models projected that rainfall will decrease during March–April and increase during November–December under both SSP2-4.5 and SSP5-8.5 scenarios (Xscience, 2020).

Climate change is estimated to increase temperature by 1.4 – 5.5° C and precipitation by -2% TO 20% by the end of the 21<sup>st</sup> century. On the other hand, little is known about changes in precipitation in terms of time and space. Crop yields in the area are negatively impacted by climate change, from drought incidences and leaching of nutrients due to flooding/water logging (Adhikari et al., 2015). It is projected to overall decrease the yields of cereal crop in Africa through shortening growing season length, amplifying water stress and increasing incidence of diseases, pests and weeds outbreaks (Niang et al. 2014).

Apart from water quality and availability considerations, unsustainable rainfall caused by climate change increases the need for irrigation water (Misra, 2014). Also, it is expected that the variations in rainfall will increase the severity and frequency of occurrence of floods and drought incidences which both have negative implications on agriculture. (Watanabe et al, 2018). These occurrences are projected to significantly reduce agricultural water availability and jeopardize the rain-fed agriculture system's production (Rao et al, 2015). Increased rainfall intensity is projected to accelerate the rate of soil erosion in the future further threatening the crop productivity (Geburu et al., 2021).

### **2.3. Adaptation strategies employed in response to the changes**

Drought and heat as well as extremes of rainfall are identified as major abiotic stresses that reduce crop productivity and weaken global food security. Given the current and increasing impacts of climate change and their manifestation in changing rainfall patterns, the presence

and magnitude of these stresses are likely to increase hence requiring the urgent need for effective strategies to cope with (Lamaoui, 2018).

According to Lamaoui et al, (2018) there is likely an increase in temperature and precipitation by the end of the 21<sup>st</sup> century, with a greater uncertainty in the temporal and spatial variability of precipitation events under which precipitation patterns' changing conditions pose significant challenges to crop production and food security.

In rain-fed agriculture, on the available soil moisture is insufficient to meet the increasing demand for water in terms of rainfall distribution and potential changes caused by climate change (Forschung and Bildung, 2013). As an adaptive measure, farmers select a combination of crops based on the prevailing climate; nevertheless, rather than heat stress, many crops will be more impacted by water stress, which is brought on by increasing evapotranspiration and rainfall variability thus the need to diversify crops has been considered (Raza et al, 2019).

As such, rain-fed farming is typically limited to 3–6 months during the rainy season and the crop yields are subjected to weather-driven fluctuations. The development and dissemination of drought tolerant crop cultivars could also help minimize the altered rainfall pattern impact during periods of long dry spell (Adhikari, 2015)

Development of small-scale irrigation schemes, drip irrigation in particular is one feasible option for maintaining future crop productivity. For smallholders, shallow and hand-dug wells supplement water limitations, especially during the dry season. Rainwater harvesting and storage from ground surfaces and rooftops for use during the dry season is another option been used to cope with rainfall variability (Bernard and Joyfred, 2020).

There are many on-farm adaptation strategies that can be put in place to reduce the likelihood of future adverse situations. Depending on the severity of climate change events, these adaptation strategies can be incremental, structural or transformational (Panda,2018). Changing the current systems to reduce effects, such as planting dates, crop varieties, plant density and nutrient water management strategies, is known as incremental change. These changes can valuably reduce the negative effects of climate change on crops, reducing their vulnerability (Meng et al, 2017)

There are a number of farm-level adaptation strategies that may be put in place to reduce the likelihood of unfavorable future conditions. Depending on how severe the effects of climate change are, these adaptation strategies might be incremental, systemic, or transformative (Panda, 2018). Modifying the current system to reduce consequences, such as altering planting dates, crop kinds, plant density and nutrient and water management techniques, is known as incremental adaptation. By making these adjustments, the negative effects of climate change on crop production can be significantly mitigated, reducing the susceptibility (Meng et al, 2017).

Farmers may need to adopt systems adaptation (such as switching to resilient crops, crop diversification, or precision agriculture) or even transformational adaptations (look for alternate ways to get income) when the incremental adaptations are no longer sufficient (Panda, 2018). To better assist in formulating potential coping measures, further research is needed to assess the impacts of climate change on regionally important staple food crops (Adhikari, 2015)

The changing climate has been projected to have significant impacts on global major crops, which may have drastic implications for food security for the increasing world population. Zhao et al. (2017) employed multi-method analysis to find out the future climate impacts on global major crops and suggested in the findings crop-specific and region-specific adaptation strategies to ensure food security for the increasing global population. Similarly, Raza et al. (2019) also emphasized that climate-smart agriculture is the only way to sufficiently lower the negative impact of climate variations on crop adaptation and global crop production.

According to Smith et al, (2020)there is great potential benefits of reducing anthropogenic emissions of methane and black carbon in mitigating climate change since they partly contribute to climate change denoting that reducing these emissions would result in multiple climate and health benefits, including increasing annual crop yields by 30 to 135 million metric tons due to ozone reductions. Looking at the findings, addressing anthropogenic factors and adoption of institutional policies in support to mitigate the impacts of climate change on crops is been valued.

Abdalla et al. (2019) revealed in their study on impact of cover crops on nitrogen leaching, soil organic carbon sequestration and grain yield of primary crops that cover crops decreased nitrogen leaching and increased soil organic carbon sequestration, though they also reduced grain yield of the primary crop to a less extent. This finding also explores the complex trade-offs involved in implementing adaptation strategies and thus highlighted the need for comprehensive assessments of their potential impacts in that some practices may still show negative effects.

#### **2.4. Perceived effectiveness of the available strategies**

The application of the adaptation strategies varies from region to region depending on agricultural practices being carried out. The effectiveness of these strategies to reduce the impacts of changing rainfall pattern have undergone some reviews under which several studies have examined the perceived effectiveness, giving valuable insights.

A study conducted by Adhikari et al, (2015) examined farmers' perceptions of climate change and their adaptation strategies in Nepal. It found that farmers perceived changes in temperature and rainfall patterns and employed various adaptation strategies, including changes in cropping patterns and water management practices. This therefore indicated their applicability and the importance of understanding local perceptions and effective adaptation strategies to be developed. Many farmers view rainwater harvesting as a practical and locally appropriate solution. They appreciate having an additional water source during dry spells, especially for crop irrigation and livestock needs. Rainwater harvesting is considered as a way to build resilience against irregular rainfall patterns and this could as well be less effective in different agricultural community or crop production activities undertaken.

Abbas et al. (2022) went ahead to conduct a study on the significance of exploring how farmers understand rainfall fluctuations and changes in anticipating the impacts of changing climate patterns and emphasized that, only when a problem is found and understood will appropriate steps be taken to adapt to it. Similarly, the review by Cairns et al (2012) also contributed to this discussion by focusing on maize production in a changing climate and gave insights into the impacts of changing climate on maize production as well as adaptation and mitigation by planting of drought resistant crop varieties that farmers view much as a hope

during prolonged dry periods and having access to seeds that can withstand water scarcity was also crucial for their livelihoods. These varieties were actually perceived as a lifeline for maintaining crop yields.

Feola (2015)'s review explored the concept of societal transformation in response to global environmental change. It emphasized the need for transformative adaptation strategies that address the root causes of vulnerability and enhance societal resilience. The study valued consideration of the effectiveness of adaptation strategies in the context of broader societal changes which included community-based flood preparedness where Communities appreciated early warning systems that help them prepare for floods. Timely alerts allow farmers to safeguard their crops, livestock and property which make real sense of community involvement in disaster preparedness.

According to Osbahr et al (2008) in his study in Senegal which examined agricultural adaptations to climate change considering changes in crop varieties and planting dates, farmers appreciated local contexts and knowledge systems in developing effective adaptation strategies along with the recognized benefits of terracing in preventing soil erosion and retaining moisture in the hilly regions where the fields were seen as more productive and stable during heavy rains.

Lwasa et al (2017) conducted a review of adaptation practices to climate change in Africa which suggested that even though various adaptation strategies are being implemented, their effectiveness is often limited resource constraints, lack of access to information and technology and therefore emphasized the need for context-specific and participatory approaches to adaptation. From the studies, not all implemented strategies work out as farmers may anticipate.

## **2.5. Challenges faced by farmers in implementing the adaptation strategies**

Climate change poses a serious threat to global food security, with agriculture being one of the most vulnerable sector (Hansen et al., 2019). Changes in rainfall, temperature, and weather negatively affect agricultural production leading to low crop yields, reduced water availability for crop growth and increased pest and disease pressure (Bryan et al., 2013). To avoid these effects, farmers would need to adopt some strategies to enhance their resilience

but various challenges still exist which hinder the successful implementation and sustainability of these strategies.

Meanwhile agriculture is the dominating economic activity in the region, there is still low productivity and lack of modern farming technologies (Chauvin et al. 2012), being largely rain-fed and thus, their success is sensitive to climate variability (Rao et al, 2015). Farmers' ability to adapt to the climate change is limited by the inadequate access to climate information and forecasting tools (Hansen et al., 2019). There is also lack of reliable and timely climate data making it difficult for farmers to make informed decisions about planting, irrigation and harvesting coupled with the complexity of climate information and the need for specialized skills to interpret them (Morton et al 2015).

According to Bryan et al (2013), many farmers face limited financial resources to invest in adaptation measures, implementing strategies such as rainwater harvesting systems which require large capacity tanks, crop diversification, or terracing require upfront costs for infrastructure, seeds and training which may not be put to practice without adequate funding, leading to vulnerability to changing rainfall patterns. The high upfront costs of implementing adaptation strategies, such as purchasing drought-tolerant seeds, constructing irrigation systems and investing in climate-resilient agricultural technologies greatly affect farmers with limited financial resources and those who lack of access to credit in adapting to rainfall variability (Gommes et al., 2016).

Vermuelen (2012) reported that farmers often lack awareness about available adaptation options and their benefits hence may not understand the importance of climate-resilient practices or have access to relevant information. The insufficiency in knowledge hinders the adoption of effective strategies which by outreach programs, workshops and extension services are catered for. The limited availability of climate-resilient crop varieties as well hinders farmers' ability to adapt to changing environmental conditions which necessitates development and dissemination of climate-resilient varieties as farmers often lack access to these improved varieties, making them vulnerable to climate related changes or shocks (Lal, 2015)

Some adaptation strategies involve application of technology in which farmers do not have the necessary skills or technical know-how to implement these solutions given the lack of advanced tools required and the necessary training to promote user-friendliness of the technologies. In addition, inadequate irrigation and water management systems exacerbate the challenges farmers face to adapt to climate change with effect of inadequate water storage, inefficient irrigation systems and lack of harvesting methods thus contributing to water scarcity which as well reduces the ability of farmers to adapt to changing rainfall patterns (FAO, 2017).

Environmental changes increase pest and disease pressures as warmer temperatures and alteration of rainfall patterns are changing the distribution and spread of viruses and diseases, it becomes hard for farmers to effectively manage these risks in addition to soil erosion and nutrient depletion due to soil erosion which further compromise the ability of farmers to adapt to climate change (Lal, 2015).

According to Horton et al., (2010), limited institutional support and policy frameworks for climate change adaptation exacerbate the challenges faced by farmers. The lack of policies and programs supporting climate change adaptation, inadequate extension services and limited access to climate information and decision support tools hinder farmers' ability to adapt to climate change.

In the case of land and property rights, unclear land ownership or insecure employment can discourage long-term investment because farmers would be reluctant to use adaptive strategies in case they lose their land. Secure land rights are essential for sustainable change. Legislative reform and community-based land policy can address this challenge.

Climate information is important for smallholder farmers in Tororo to manage climate-related risks and adapt to climate change though there is a significant gap in the provision of climate information that adequately meets farmers' needs in ascertaining when to plant.

Most farmers therefore, rely on indigenous knowledge (IK), where local indicators and experiences are used to observe and forecast weather conditions. While IK-based forecasting is inbuilt and established in many communities in Uganda, coordinated research and

systematic documentation of IK for weather forecasting, including accuracy and reliability of IK is largely lacking. (Radeny et al., 2019)

Deressa et al., (2010) compared adaptation options and constraints in Ethiopia and South Africa. They found that farmers in both countries faced similar challenges, including limited access to finance, lack of information and technical support and inadequate infrastructure. The study emphasizes the importance of developing policies and strategies to address these barriers to promote successful change.

In Vietnam, the challenges rice farmers face in adapting to climate change included water scarcity, salinity, pests and diseases. The study highlighted the need for integrated and participatory approaches to address these challenges and increase the resilience of rice-based agricultural systems (Dang et al., 2012).

Seo et al., (2010) examined trends and challenges in climate change adaptation in Sub-Saharan Africa. They identified key challenges, including limited access to credit, lack of extension services and inadequate infrastructure. The study highlighted the importance of addressing these challenges to promote successful adaptation.

Kurukulasuriya and Mendelsohn (2006) assessed the impact of climate change on African agriculture and identified challenges such as water scarcity, soil degradation and pest and disease outbreaks. They emphasized the need for sustainable land management practices and policies to address these challenges and enhance the resilience of African agriculture.

## **2.6. Areas of improvement and recommendations**

Despite the existing research insights, many knowledge gaps remain in the literature in which case Bangalore (2015) and Adhikari (2015) carried out studies in addressing the impacts of climate change on poverty and primary crop production in east Africa. Their findings noted the need for more research to understand the specific adaptation strategies that work best at local and contextual levels.

Future research directions should focus on developing crop-specific and region-specific adaptation strategies that consider the complex interactions between climate change, abiotic stresses and crop productivity. (Rezaei et al, 2023). Additionally, more studies are needed to

evaluate the trade-offs and synergies between different adaptation strategies, such as cover crops, climate-smart agriculture and emissions reduction, to identify the most effective approaches for mitigating the impacts of changing rainfall patterns on crops. This will be essential to ensure global food security in the face of climate change (Arif et al, 2020).

A study led by the University of Maryland found that plants in arid regions such as the American West benefit from heavy rainfall while those in naturally moist regions suffer the same fate creating the need to response of the plant species to varied length of rainfall and dryness.

In the Midwestern United States where plants are more susceptible to shifts in rainfall, selection of crop varieties that can withstand these changes is important in maintaining agricultural productivity of which selection of plant species and crop varieties that are resilient to the expected changes in rainfall patterns is considered to maintain productivity.

Beside, Bates et al (2008) recommended implementations of ecosystem-based approaches such as habitat engineering, rehabilitation and natural infrastructure development to mitigate the effects of changing rainfall patterns by restoring wetlands and planting cover crops helping to reduce the severity of flood impacts and control erosion, enhancing soil health and water retention.

Feola (2015)'s review explores effective Early Warning Systems (EWS) to provide timely alerts for extreme rainfall events with Community engagement in EWS design and response planning enhances effectiveness. This recommendation has been noted along with training local volunteers to monitor river levels and alert residents during heavy rainfall to enable the communities prepare for floods. In addition, climate smart agriculture has adopted practices including rainwater harvesting and efficient irrigation to improve water use efficiency and adopt to changing rainfall patterns. Support farmers to manage water resources irrigation in regions experiencing longer dry periods and those with stronger downpours.

Focus on soil conservation practices by Muchuri (2019) such as no-till farming, mulching and enhancing soil organic matter; which are cost friendly practices improve water retention and resilience against changing rainfall patterns with practices of using organic mulch to protect soil from heavy rain impact can prevent erosion and maintain soil structure during intense

downpours. Along with that, developing integrated water resource management strategies that include small-scale water storage facilities and promote efficient irrigation techniques as such, constructing ponds and tanks to capture excess rainwater during heavy downpours.

The assessment of adaptation strategies to changing rainfall patterns in Paya, Tororo District, reveals the importance of implementing various strategies to cope with the impacts of climate change. Crop diversification, water harvesting and storage, improved irrigation systems and climate information services are among the key strategies employed in this context (Muchuri and Nhamo, 2019). These strategies have shown promising results in enhancing resilience, improving agricultural productivity and reducing vulnerability to changing rainfall patterns. However, the long-term performance and sustainability of these strategies in the face of ongoing climate change needs to be examined (Altieri and Nicholls, 2017).

## **CHAPTER THREE;**

### **3. METHODOLOGY**

#### **3.1. Research design**

This study adopted descriptive survey research design to assess the adaptation strategies employed by farmers in Paya sub county, Tororo district Uganda, to mitigate the impacts of changing rainfall patterns on crop production. The descriptive survey approach allowed for collection of quantitative and qualitative data to describe and analyze the current situation, identify patterns and draw conclusions about the chosen population.

#### **3.2. Study Area:**

Tororo District is a district in the Eastern Region of Uganda situated at Coordinates: 00°45'N 34°05'E with a total land area of 1,196.4 km<sup>2</sup> (461.9 sq. mi) and a population (2012 Estimate) 487,900, making up density of 407.8/km<sup>2</sup> (1,056/sq. mi). The town of Tororo hosts the district headquarters.

Tororo District is bordered by Mbale District to the north, Manafwa District to the north-east, Kenya to the east, Busia District to the south, Bugiri District to the south-west and Butaleja District to the north-west. Tororo, the largest town in the district holds the district headquarters, approximately 230 kilometers (140 mi), east of Kampala, the capital and largest city of Uganda

Agriculture is the backbone of the districts' economy. Most of the districts' produce is consumed locally or sold in the urban areas within the district. Crops grown include; millet, cassava, peas, beans, sweet potatoes, simsim, sunflower, cotton, onions, rice, maize.

The district consists of several divisions and the sub counties including Paya sub county situated in Kisoko (West Budama) and its geographical coordinates are 0° 49' 56" North, 34° 0' 53" East. The sub county is constituted by three parishes and sixty-one villages.

### **3.3. Description of the population**

The sampled population consisted of male and female farmers with different age engaged in crop production with different levels of farming experiences and education. Individuals with different levels of education without formal education, primary education, secondary or tertiary education The farmers measured varied in their experience in farming, some were traditional farmers with years of experience, some were newcomers to the crop production sector.

The exact population of farmers in Paya Sub County wasnot specified but the study aimed to survey a representative sample of 65 farmers who were actively engaged in crop production and were willing to participate in the study.

### **3.4. Sampling strategy**

Probability sampling strategy specifically stratified random sampling technique was used to select a representative sample of farmers from different villages, farming crop types and adaptation strategies employed in Paya.

Purposive sampling method was used to select a smaller subset of farmers who had implemented various adaptation strategies and had experienced different impacts of changing rainfall patterns.

### **3.5. Research approach; Data collection methods**

The study adopted a mixed-methods approach, combining qualitative and quantitative data collection techniques for both primary and secondary data sources. Primary data was collected through household surveys, on-field observations and key informant interviews. The surveys were conducted using a structured questionnaire, while the interviews were guided by semi-structured interview guides. Secondary data was obtained from relevant literature, reports and documents regarding the topic of study.

### **3.6. Data quality control**

Sample selection of participants was carried out using random sampling techniques to ensure representativeness data and minimize bias. Triangulation/Multiple sources of data was used to cross-validate the findings.

Well-structured questionnaires that were clear, concise and relevant to the research objectives were used to obtain information from the population. The questionnaire was piloted with a small group of farmers to identify and address any ambiguities or inconsistencies.

### **3.7. Data analysis**

The study used thematic analysis, identifying and analyzing recurring themes in qualitative data, such as interviews and questionnaires. This approach helped to shape the patterns and meanings of the participants' responses.

Content analysis was also used to systematically analyze and classify textual or visual data, identifying specific issues associated with changing precipitation patterns and the effects of adaptation strategies.

The aim of the routine comparative analysis was to maintain comparisons as data were collected, allowing for the optimization and development of themes and categories throughout the research process.

Case studies also focused on detailed examination of individual issues in the Paya community, providing a more detailed understanding of the specific experiences associated with changing rainfall patterns.

Finally, narrative research examined the stories and narratives shared by participants, examining how individuals constructed their experiences and made sense of strategies for adaptation in a changing environment in Paya.

### **3.8. Ethical considerations**

**Informed consent:** All participants were fully informed about the purpose, procedures, potential risks and benefits of the study before participating in the study. They were given questionnaires and voluntary consent to participate.

**Confidentiality:** All personal information collected from participants was kept confidential and secure. The data were anonymized to protect the identity of the participants and only the questionnaire did not contain provision for name of respondents.

**Benefits:** The purpose of the study was to also benefit the community by identifying effective adaptation strategies to mitigate the impacts of changing rainfall patterns within the locality. The findings of the study were shared to effective decision-making.

**Non-Maleficence:** Steps were taken to minimize any potential harm to participants. This included ensuring that the research did not disrupt their daily activities or cause any emotional distress.

**Respect for Participants:** The study respected the cultural norms and values of the community in Paya and participants were treated with respect and their perspective was valued throughout the research process.

**Compliance:** The study was conducted in compliance with all relevant laws, regulations and ethical guidelines, including those that were set forth by Busitema University and relevant ethics committees

## CHAPTER FOUR;

### 4. PRESENTATION OF DATA, ANALYSIS AND DISCUSSION

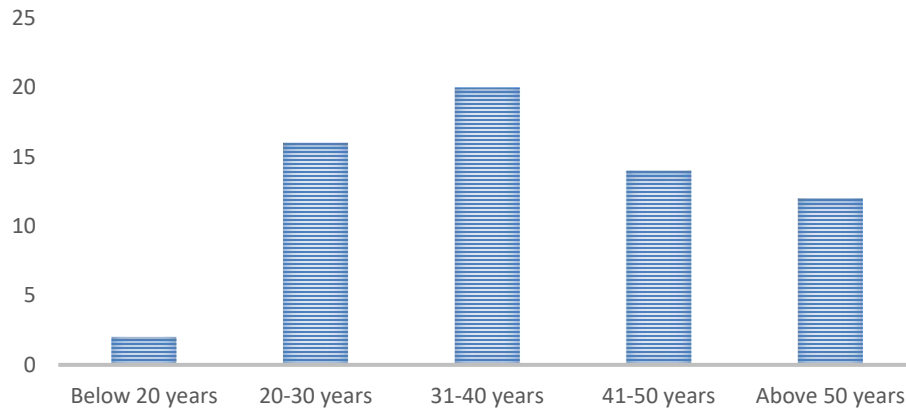
#### 4.1. Age distribution of farmers

According to the results, the age distribution of farmers in the study area indicated that the majority of farmers were in the 31-40 years' age group, representing 31.3% of the total sampled respondents. This was followed by the 20-30 years' age group, which was constituted by 25.0% of the farmers. Farmers in the age group of 41-50 years made up 21.9%, while those more than 50 years accounted for 18.8%. The smallest proportion of farmers which was at 3.1%, were under 20 years of age reflecting a relatively balanced age range among the farming population, with a notable percentage of individuals in their prime working years as shown in the table below.

**Table 4:1; Age distribution of farmers**

<b>Age group</b>	<b>Number Of Farmers</b>	<b>Percentage Of the Total</b>
Below 20 years	2	3.1%
20-30 years	16	25.0%
31-40 years	20	31.3%
41-50 years	14	21.9%
Above 50 years	12	18.8%
<b>Total</b>	<b>64</b>	<b>100</b>

## NUMBER OF FARMERS IN VARIOUS AGE GROUPS



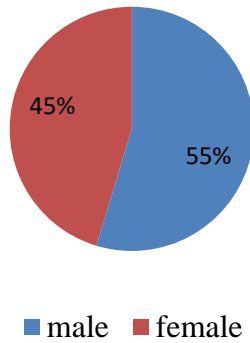
**Figure 4:1: A graph showing the number of farmers at different age groups**

The results from the demographic information therefore indicated a diverse age distribution among farmers in Paya, with the highest proportion in the 20-40 years' age range, suggesting a mix of younger and middle-aged farmers actively engaged in agriculture. This gives insights for tailoring interventions to the needs of different age groups in a way that the young farmers benefit from training on innovative farming methods and adoption of technology, while older ones might require some support with traditional practices and sustainable agriculture methods. Farmers in this majority age group are an indication of healthy working population as well as the level of human capital as suggested by the SLF.

### **4.2. Gender Distribution of Farmers**

The results also show the gender distribution of farmers in Paya, Tororo district to have more males engaged in farming than females. The data showed that male farmers constitute a slight majority, representing 54.7% of the total sample while female farmers constituted 45.3% of the farming population. This near parity in gender distribution indicated the significant role both men and women play in agricultural activities especially of crop production within the district.

### Gender distribution of farmers



**Figure 4:2: Gender Distribution of Farmers**

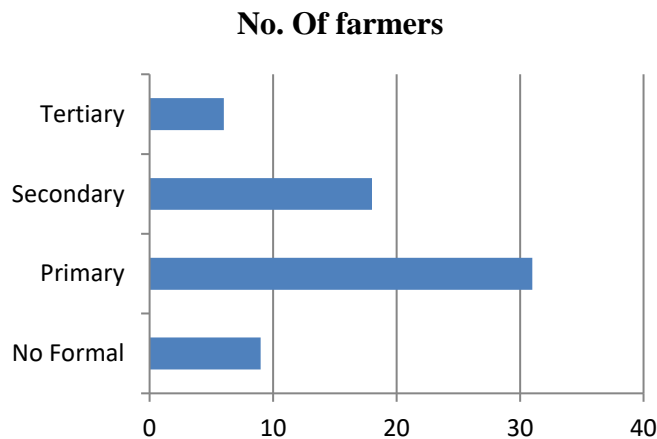
Thus, in terms of gender of the respondents, the gender ratio showed that a slight majority were male farmers, which explores the gender dynamics within the agricultural community of Paya. This as well portrays active participation of both men and women in crop production given the slight difference in the gender ratio. Also, considering the gender dynamics in the agricultural context could be important for the development of gender-sensitive agricultural policies and programs which ensure equitable access to resources, training and support services for both male and female farmers. With regard to the SLF, it further incorporates an aspect of social capital with participation of both males and females in agriculture.

#### **4.3. Educational Level of Farmers**

The educational levels of farming population presented in the table below showed that the majority of farmers had completed primary education, accounting for 48.4% of the total respondents. This was followed by those with secondary education at a moderate rate of 28.1%. A smaller percentage of farmers of about 14%, had not obtained formal education, while 9.4% had attained tertiary education. This distribution suggests that most farmers have at least basic education, which could influence their ability to adopt new farming practices and technologies in the face of climate variability.

**Table 4:2; Educational Level of Farmers**

<b>Education Level</b>	<b>No. Of Farmers</b>	<b>% Of Total Respondents</b>
No Formal	9	14.1%
Primary	31	48.4%
Secondary	18	28.1%
Tertiary	6	9.4%
<b>Total</b>	<b>64</b>	<b>100.0%</b>

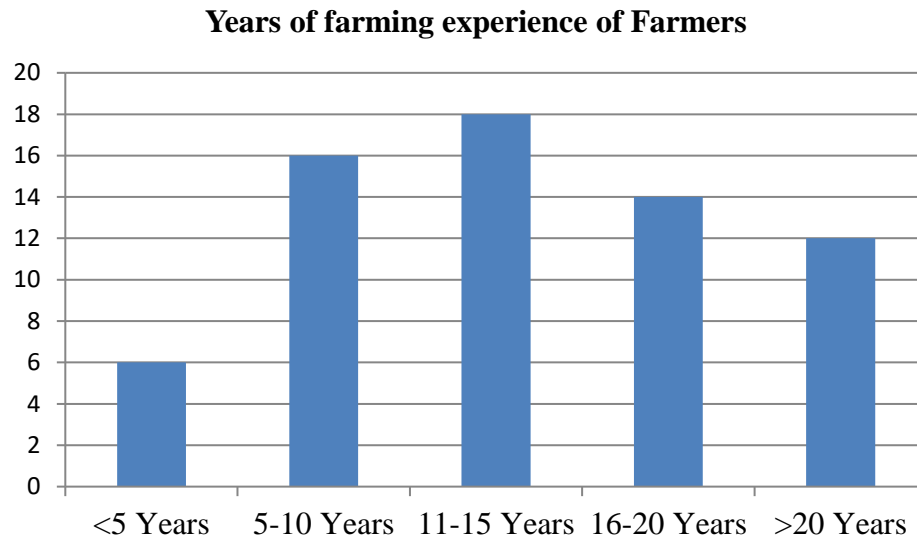


**Figure 4:3; Educational level of farmer**

Most farmers have attained primary and secondary education levels which could also be useful in efficient decision making of agricultural practices and adaptation strategies. In most cases, farmers with higher education levels can be more willing to adopt innovative practices and technology, while those with lower education levels might require more informative and practical training before taking relevant decisions. The educational level of farmers also reflects knowledge and skills in farming which are components of human capital.

#### 4.4. Farming Experience of Farmers

The resulting data also displayed the experience of farmers in the study area with an indication that the largest group of farmers had between 11-15 years of experience, representing 28.1% of the total. This was followed by those with 5-10 years of experience (25.0%) and those with 16-20 years of experience (21.9%). Farmers with more than 20 years of experience constituted 18.8%, meanwhile those with less than 5 years of experience accounted for the smallest percentage which was 9.4% implying a relatively experienced farming population, which could be beneficial for the implementation of advanced farming techniques and practices with indigenous expertise.



**Figure 4:4; Farming Experience of Farmers**

Summarily, the majority of the farmers had between 5-15 years of farming experience, which indicates a mixture of relatively new entrants and more seasoned farmers hence their knowledge base and adaptive capacity to changing environmental conditions differed. Seeking expertise on the best options from the more experienced on the local trends could enlighten the new entrants on the best practices while they may also be curious for new technologies, as in human capital available within the community.

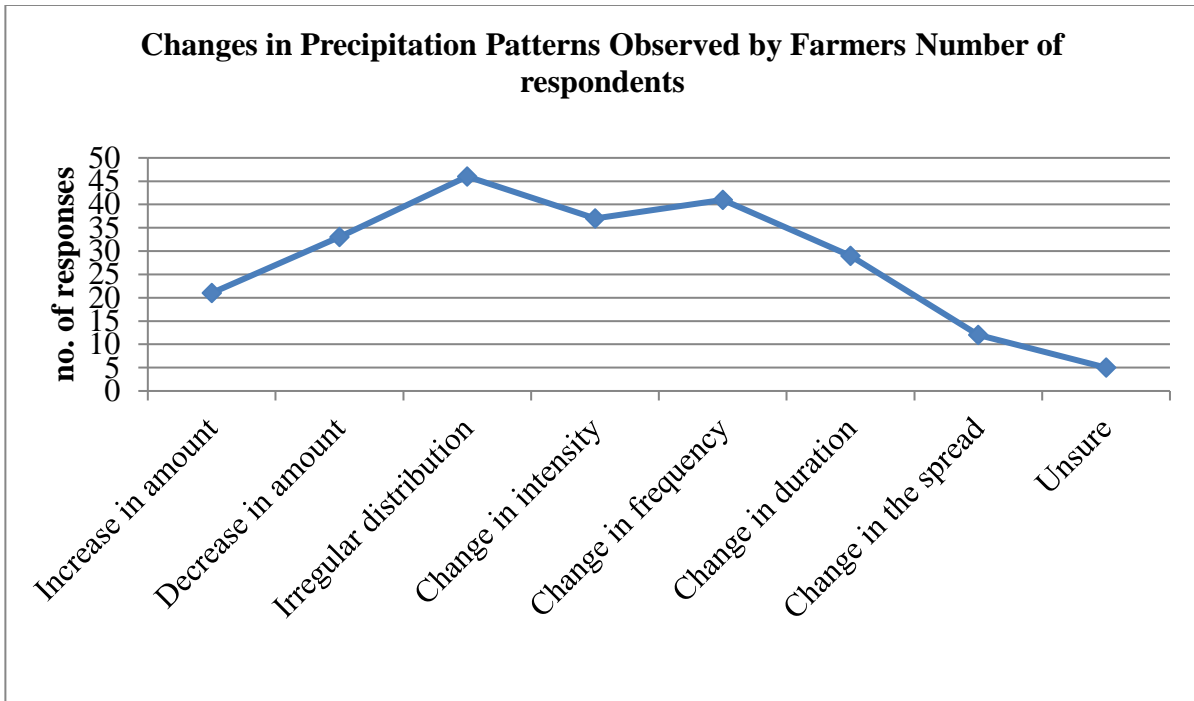
#### 4.5. Changes in Precipitation Patterns Observed by Farmers

There were different changes in precipitation patterns that were observed by varied proportions of the respondents in Paya, Tororo district, ranging from high irregularity of rainfall distribution (79.1%) to a minimal response about the changes in the spread (18.8%) meanwhile 7.8% of the respondents were not really sure if the rainfall patterns had changed as summarized in the following table. The observations highlight the complexity and variability of climate impacts on agricultural activities in the region and individual farmers' experiences which were important for understanding how climate variability affected agricultural practices and crop productivity. The table below presents the various changes in precipitation patterns observed by farmers.

**Table 4:3; Changes in Precipitation Patterns Observed by Farmers**

<b>Change in precipitation</b>	<b>Number of respondents</b>	<b>% of respondents</b>
Increase in amount	21	32.8%
Decrease in amount	33	51.6%
Irregular distribution	46	71.9%
Change in intensity	37	57.8%
Change in frequency	41	64.1%
Change in duration	29	45.3%
Change in the spread	12	18.8%
Unsure	5	7.8%

From the above table, there were indeed changes in the variability of rainfall observed by farmers in the study area. For further comprehension, the graph below shows the reported changes that farmers noted basing on their farming experience in the region.



**Figure 4:5: Observed changes in precipitation patterns**

Considering the different aspects of climate variability, a significant majority (71.9%) of farmers had observed irregular distribution of rainfall as well as changes in frequency reported by 64.1% of the respondents which attests that the area had been a victim of climate variability. More so, many farmers noted changes in rainfall intensity (57.8%), specified to decrease in the amount (51.7%) and duration (45.3%). Predominantly, the results indicate changes in the annual distribution of rainfall, changes in the frequency, intensity and the amount. This calls for an understanding of the roots of these changes so as to combat any changes that may have negative impact on the agricultural practices in the area because, this could compromise the existing physical capita such as farming infrastructures and also the natural capital.

#### 4.6. Impacts of Observed Changes in Precipitation Patterns

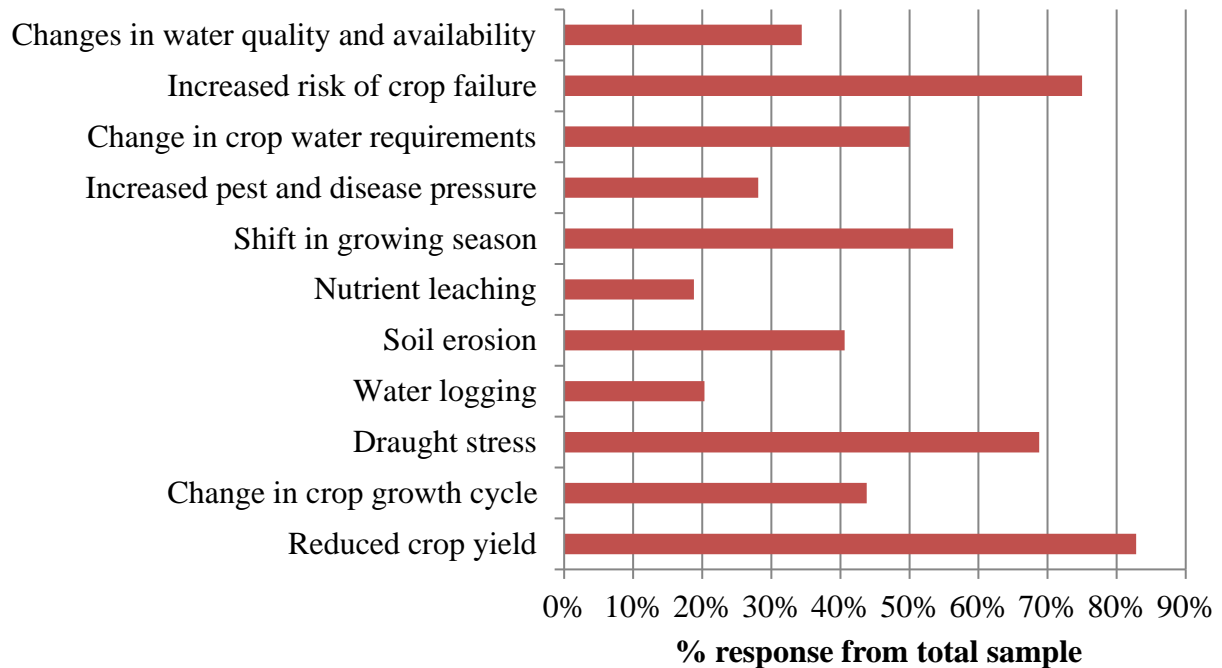
The impacts of precipitation patterns variability reported by the farmers in the area showed that, the most significant impact was on the reduction of crop yields which was reported by 82.8% of the total respondents and a small report of nutrient leaching by only 18.8% of the respondents. These impacts depict the challenges and vulnerabilities faced by agricultural practices due to climate variability as shown in the table below.

**Table 4:4; Impacts of Observed Changes in Precipitation Patterns**

<b>Impacts of observed changes</b>	<b>Number of respondents</b>	<b>% response from sample</b>
Reduced crop yield	53	82.8%
Change in crop growth cycle	28	43.8%
Draught stress	44	68.8%
Water logging	13	20.3%
Soil erosion	26	40.6%
Nutrient leaching	12	18.8%
Shift in growing season	36	56.3%
Increased pest and disease pressure	18	28.1%
Change in crop water requirements	32	50.0%
Increased risk of crop failure	48	75.0%
Changes in water quality and availability	22	34.4%

Additionally, there were also reports for loss of biodiversity, changes in soil structure and increased cost of farming, coupled with fears of crop failure as impacts of the existing changes in rainfall patterns. Below is a graphical representation of the farmers' experiences of the impacts of rainfall variability.

## Impacts of Observed Changes in Precipitation Patterns



**Figure 4:6: Impacts of precipitation changes observed**

This indication of variability in precipitation timing and intensity can disrupt planting schedules and affect crop growth cycles. Besides, they affect soil moisture levels and water availability, influencing crop water requirements and affecting overall crop productivity.

The farmers' observations thus reflect localized impacts of climate change, showing the need for adaptive strategies which can accommodate unpredictable rainfall patterns. The perceptions therefore serve as a basis for prioritizing resilience-building measures which may include water management and crop diversification. These impacts highlight the diverse challenges faced by farmers, including reduced crop yields, shifts in growing seasons and increased vulnerability to pests and diseases. From the overall observations, it is seen that these impacts required adaptive strategies and resilience-building efforts directed to local agricultural practices.

The majority of the farmers 82.8% experienced reduced crop yields. This being with direct economic consequences of rainfall variability on food security and livelihoods in the region,

affirms the vulnerability. Drought stress (68.8%) and change in crop water requirements reported cumulatively with other negative effects increased the risk of crop failure which was experienced by over 75% of the total respondents. The higher rate of drought stress (68.8%) and incidences of water logging noted (20.3%) reflect erratic patterns of intense short period rains resulting in water logging and then followed by prolonged sunshine and intensity which are as well factors resulting in reduction of yields. Additionally, the water logging could be an experience from individuals practicing farming in the swampy areas which are vulnerable to that effect.

The compounding results of the impacts of Soil erosion (40.6%), nutrient leaching (18.8%) and increased pest and disease pressure (28.1%) were identified as environmental consequences exacerbated by altered rainfall patterns and can collectively be directed or projected towards reduction of crop productivity. With these diverse impacts, it affirms that the farmers in the region had experienced much negative impacts of these changes and will need support to enhance their agricultural productivity amidst these changes.

#### **4.7. Adaptation Strategies Employed by Farmers**

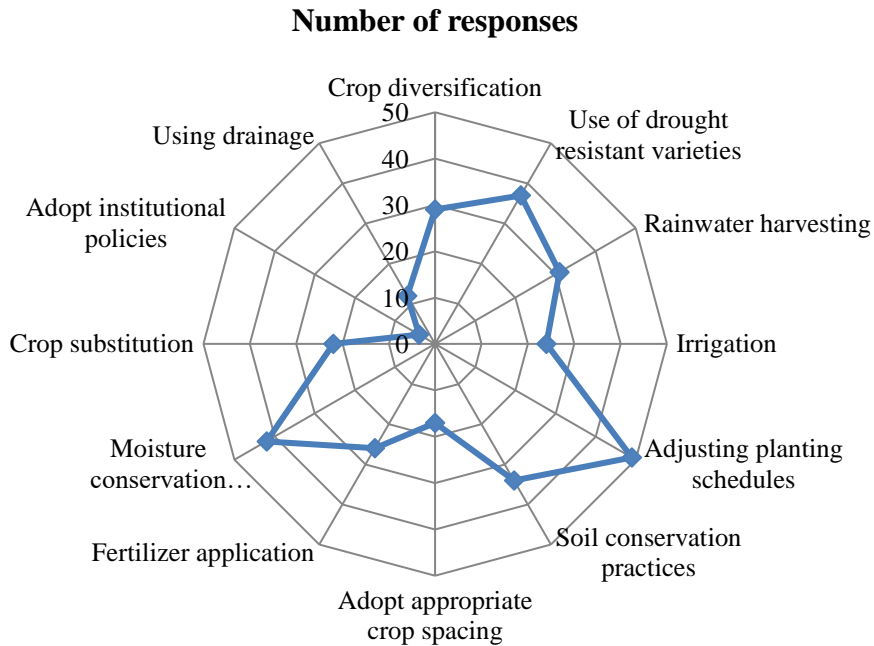
From the data, the greatest proportion of the farmers had considered adjusting the planting dates to the anticipated onset of rains while practicing moisture conservation methods. Only a small fraction of the farmers had considered institutional adaptive strategies and the practice of drainage. The adaptation strategies employed by farmers in response to changing rainfall patterns in the area are summarized in the table below, giving the number of farmers who have tried out one or more of the strategies to cope with changing rainfall patterns impact on crop production.

**Table 4:5; Adaptation Strategies Employed by Farmers**

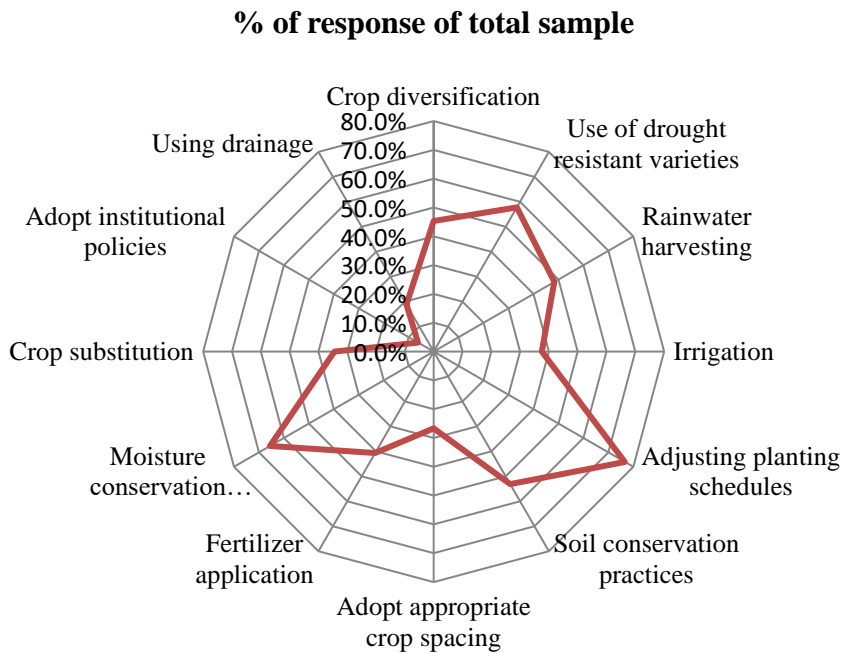
<b>Adaptation strategy</b>	<b>Number of responses</b>	<b>% of response</b>
Crop diversification	29	45.3%
Use of drought resistant varieties	37	57.8%
Rainwater harvesting	31	48.4%
Irrigation	24	37.5%
Adjusting planting schedules	49	76.6%
Soil conservation practices	34	53.1%
Adopt appropriate crop spacing	17	26.6%
Fertilizer application	26	40.6%
Moisture conservation practices	42	65.6%
Crop substitution	22	34.4%
Adopt institutional policies	4	6.3%
Using drainage	12	18.8%

Besides that, a few farmers also presented that, improved seed storage and attending trainings from anywhere they find productive even across regions, had been some of the ways they tried to help themselves to cope with the climate variability

The data collected was analyzed using thematic analysis guided by the sustainable livelihoods framework which consisted of natural, physical, human and social capital. Recurring themes were derived from the responses on the adaptation strategies farmers had employed as this showed varying numbers of farmers practicing the measures. Below is a graphical representation of number of farmers who were engaged in the different strategies, and percentage representation of the total respondents.



**Figure 4:7: Adaptation strategies employed**



**Figure 4:8: Percentage of farmers practicing the strategies**

As mitigation measures to the previously discussed negative consequences (section 4.6), the above data graphs show a bigger fraction of farmers practicing adjustment of the planting schedules, carrying out moisture conservation practices and planting drought tolerant crop varieties including sorghum. Nearly half (45.3%) of farmers have diversified their crops, spreading risks associated with climate variability and enhancing resilience to adverse weather. This knowledge of diversity is a reflection of human capital as it involved farmers' knowledge of the best adaptive options.

Harvesting rainwater and irrigation practices have been adopted to supplement rainfall deficits, ensuring consistent water supply for agricultural activities. However, irrigation could at times be limited by water scarcity since the results indicate longer dry spells. To further strengthen the farmers, provision of large capacity rainwater harvesting equipment should be provided for use during the short erratic rainfall periods for use during the long dry spells. These collectively indicate natural capital (rainwater) and physical capital (irrigation infrastructure) utilized in the study area.

Also, a significant proportion/majority of the farmers of up to 76.6% adjusted planting schedules in order to improve crop production, benefiting from the optimum growing conditions at the targeted time as a way of dealing with the seasonal changes in rainfall. More than half (53.1%) of the respondent farmers employed soil conservation measures to mitigate erosion and preserve soil fertility, crucial for sustaining agricultural productivity under changing climatic conditions.

#### **4.8. Perceived Effectiveness of Adaptation Strategies**

Out of all the adaptive strategies that had been put to practice, the practice of irrigation registered the highest degree of effectiveness though it had been carried out by less than half of the total respondents (37.5%) while soil conservation practices which more than half of the respondents tried out was reported less effective as well as use of drainage and appropriation of plant spacing. Farmers' assessments provided insights into which strategies are considered most effective in mitigating the impacts of changing rainfall patterns on agricultural practices. The resulting perception of the effectiveness of various adaptation strategies employed by the

farmers is summarized in the table below, showing number of farmers who had employed the strategies, providing the percentage of implementation to varying degrees of effectiveness.

**Table 4:6; Perceived Effectiveness of Adaptation Strategies**

<b>Strategy</b>	<b>Very effective</b>	<b>Effective</b>	<b>Somewhat effective</b>	<b>Less effective</b>	<b>Ineffective</b>	<b>Total</b>
Crop diversification	0	6	16	7	0	29
Use of drought resistant varieties	5	19	7	3	3	37
Rainwater harvesting	2	11	14	4	0	31
Irrigation	16	5	3	0	0	24
Adjusting planting schedules	9	10	19	9	2	49
Soil conservation practices	0	4	26	13	6	34
Adopt appropriate crop spacing	0	1	3	9	4	17
Fertilizer application	0	2	3	14	7	26
Moisture conservation practices	6	8	24	3	1	42
Crop substitution	0	3	9	7	5	22
Adopt institutional policies	0	0	2	1	0	4
Using drainage	0	4	7	1	0	12

The table below provides a summary of farmers' perceptions regarding the effectiveness of adaptation strategies in percentages. These assessments were vital in understanding the practical outcomes of different strategies and could inform future interventions and policy decisions aimed at enhancing agricultural resilience to climate variability.

**Table 4:7; Percentage effectiveness of farmers' perception**

Strategy	Very effective		Effective		Somewhat effective		Less effective		Ineffective		% of Total respondents	
Crop diversification	0	0.0%	6	20.7%	16	55.2%	7	24.1%	0	0.0%	29	45.3%
Use of drought resistant varieties	5	13.5%	19	51.4%	7	18.9%	3	8.1%	3	8.1%	37	57.8%
Rainwater harvesting	2	6.5%	11	35.5%	14	45.2%	4	12.9%	0	0.0%	31	48.4%
Irrigation	16	66.7%	5	20.8%	3	12.5%	0	0.0%	0	0.0%	24	37.5%
Adjusting planting schedules	9	18.4%	10	20.4%	19	38.8%	9	18.4%	2	4.1%	49	76.6%
Soil conservation practices	0	0.0%	4	11.8%	26	76.5%	13	38.2%	6	17.6%	34	53.1%
Adopt appropriate crop spacing	0	0.0%	1	5.9%	3	17.6%	9	52.9%	4	23.5%	17	26.6%
Fertilizer application	0	0.0%	2	7.7%	3	11.5%	14	53.8%	7	26.9%	26	40.6%
Moisture conservation practices	6	14.3%	8	19.0%	24	57.1%	3	7.1%	1	2.4%	42	65.6%
Crop substitution	0	0.0%	3	13.6%	9	40.9%	7	31.8%	5	22.7%	22	34.4%
Adopt institutional policies	0	0.0%	0	0.0%	2	50.0%	1	25.0%	0	0.0%	4	6.3%
Practicing drainage	0	0.0%	4	33.3%	7	58.3%	1	8.3%	0	0.0%	12	18.8%

The data was also analyzed using a chi square test for interdependence with the perceived effectiveness of each strategy and the type of strategy. The contingency table, observed frequencies, expected frequencies and the chi square test results are presented below.

**Table 4:8: The combined contingent table and expected frequencies for the perceived effectiveness**

<b>Strategy</b>	<b>Very effective</b>	<b>Effective</b>	<b>Somewhat effective</b>	<b>Less effective</b>	<b>Ineffective</b>	<b>Total</b>
Crop diversification	3.21	6.16	11.26	6.02	2.36	<b>29</b>
Use of drought resistant varieties	4.09	7.85	14.35	7.68	3.01	<b>37</b>
Rainwater harvesting	3.44	6.61	12.09	6.47	2.53	<b>31</b>
Irrigation	2.67	5.15	9.41	5.04	1.97	<b>24</b>
Adjusting planting schedules	5.45	10.50	19.22	10.30	4.03	<b>49</b>
Soil conservation practices	3.78	7.28	13.33	7.14	2.79	<b>34</b>
Adopt appropriate crop spacing	1.89	3.65	6.68	3.57	1.40	<b>17</b>
Fertilizer application	2.89	5.58	10.22	5.46	2.14	<b>26</b>
Moisture conservation practices	4.67	9.02	16.53	8.85	3.46	<b>42</b>
Crop substitution	2.44	4.70	8.61	4.61	1.80	<b>22</b>
Adopt institutional policies	0.44	0.85	1.55	0.83	0.32	<b>4</b>
Using drainage	1.33	2.57	4.71	2.52	0.98	<b>12</b>
<b>Total</b>	<b>38</b>	<b>73</b>	<b>133</b>	<b>71</b>	<b>28</b>	<b>343</b>

Based on the calculations, the following values were obtained:

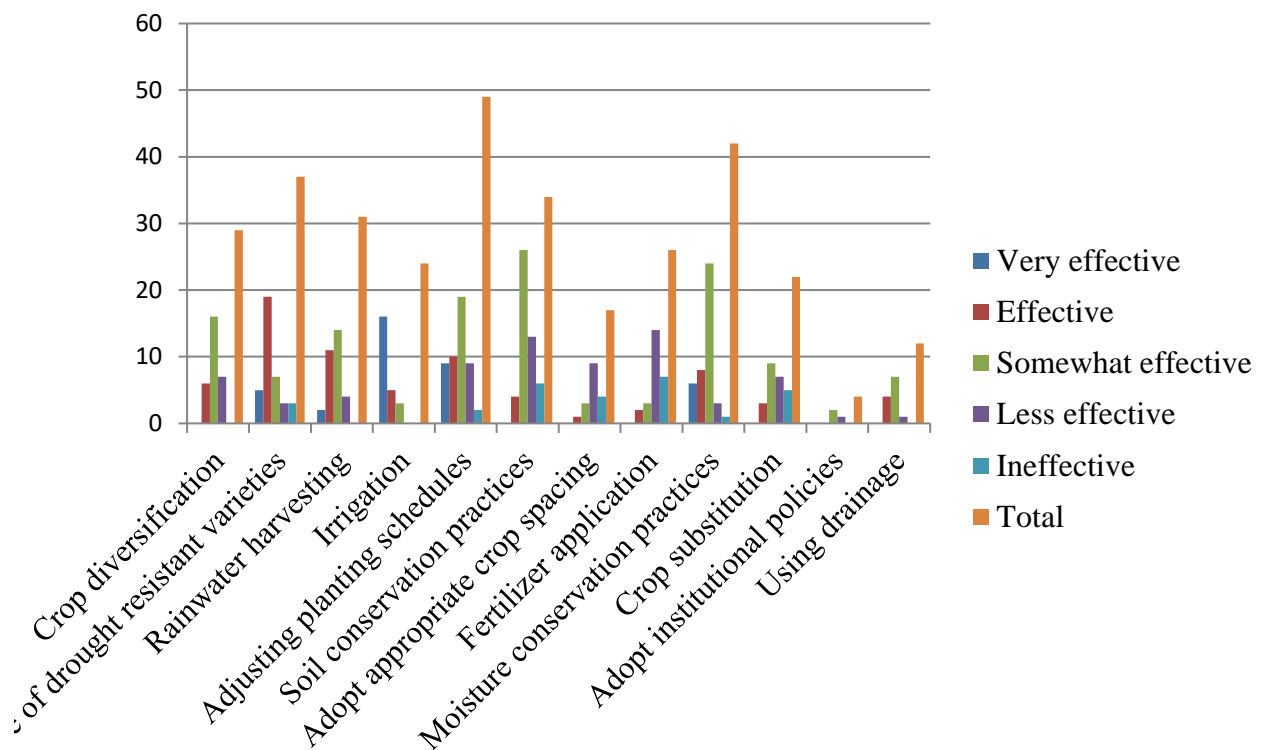
Chi square statistic ( $\chi^2$ );  $\chi^2=221.72$

p-value:  $p < 0.001$

Degrees of freedom (df):  $df = 44$

Given the chi square statistic of 221.72 and a p value less than 0.0001, we reject the null hypothesis. This indicates that there is a significant relationship between the adaptation strategies employed by farmers in Paya and their perceived effectiveness in mitigating the impacts of changing rainfall patterns on crops.

Some strategies are inherently more effective than others, as demonstrated by the large differences between observed and expected frequencies. A significant number of farmers were adjusting the dates for planting while most of those who practiced irrigation found it to be very effective.



**Figure 4:9: Perceived effectiveness of the employed strategies**

Based on the sustainable livelihood framework, the data comprised of the following recurring themes;

Water management; this theme was constituted of strategies like irrigation and rainwater harvesting of which the practice of irrigation was observed to be particularly effective by a

significant proportion of the respondents practicing it. Rainwater harvesting on the other hand indicated mixed effectiveness highlighting its interrelation with irrigation because climate adaptation requires the use of the harvested rainwater for irrigation, for crop production in particular.

Furthermore, Crop management was another theme derived; this was generated from responses on adjusting planting schedules and crop diversification. Some farmers also tried to adjust the crop spacing to utilize the available moisture in the soil though the effectiveness regarding adaption to the effects of rainfall variability on the productivity of crops was limited.

Climate adaptation also provided a recurring theme; although all the strategies investigated had their shoots towards minimizing negative effects of rainfall variability, the use of drought resistant crop varieties and narratives on moisture conservation practices highlighted their significance in addressing other aspects of climate change including pest and disease management.

Additionally, Soil and fertility management responses from farmers constituted a theme with inclusion of soil conservation practices, that showed some benefits but with some challenges. Just as fertilizer application which pointed to potential financial or knowledge barriers, the adoption of appropriate crop spacing showed low effectiveness with majority of the farmers finding it less effective indicating challenges with financial resources, knowledge or implementation.

Furthermore, institutional and policy support was singled out, with very low engagement and effectiveness denoting limited access to policy support. There is a significant gap in the utilization and effectiveness of institutional policies suggesting a need for better awareness and access to policy support.

The farmers' reports regarding the effectiveness of adaptation strategies were varied; Strategies such as adjusting planting schedules and using drought-resistant varieties were seen as somewhat effective by a significant proportion of farmers, indicating their role in enhancing agricultural resilience. From the overall implemented strategies, a greater proportion of respondents practicing irrigation report the greatest effectiveness (66.7%). This implies that irrigation which had been practiced by a few individuals is actually more

effective than the other strategies that most of the farmers had been carrying out. Considerably, some of the slightly effective measures included adjustment of planting schedules; rainwater harvesting and moisture conservation practices which also indicated a greater percentage of effectiveness.

Conversely, strategies such as fertilizer application, crop spacing and crop substitution registered less effectiveness implying that these practices do not directly enhance resilience to changing rainfall patterns. These are technically limited by drought stress; Fertilizer application for example can boost crop growth when there is ample soil moisture; adjusting the plant population may not be of help if the soil has limited nutrients in soil solution and changing the crop grown can not necessarily succeed under the same dry conditions.

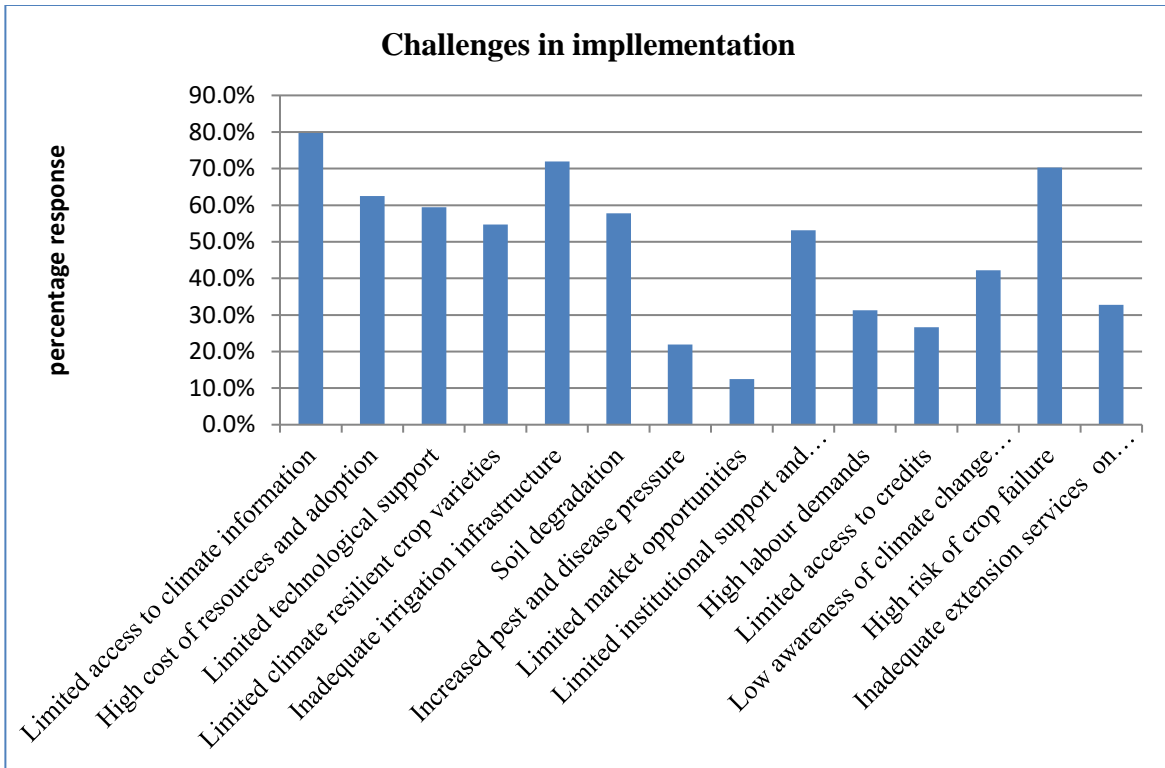
#### **4.9. Challenges in Implementing Adaptation Strategies**

Farmers also faced several challenges in practicing implementation of the adaptation strategies to curb the impacts of changing rainfall patterns in the study area (Paya sub-county). The problems faced exhibited varying degrees to which it affected or influenced adaption to climate variability as reported by the farmers. A greater proportion of farmers reported limited access to climate information and inadequate irrigation infrastructure as the major barriers.

From the sampled number of respondents who ever tried any one or more of the adaptation strategies, they reported encountering some challenges in implementing adaptation strategies to address the changing rainfall patterns as summarized in the table below. These challenges highlighted the barriers that hindered effective adaptation and resilience-building efforts in crop production practices, indicating the primary obstacles that needed to be addressed to enhance the effectiveness of adaptation strategies.

**Table 4:9; Challenges in Implementing Adaptation Strategies**

<b>Challenges</b>	<b>No. Of responses</b>	<b>% of respondents</b>
Limited access to climate information	51	79.7%
High cost of resources and adoption	40	62.5%
Limited technological support	38	59.4%
Limited climate resilient crop varieties	35	54.7%
Inadequate irrigation infrastructure	46	71.9%
Soil degradation	37	57.8%
Increased pest and disease pressure	14	21.9%
Limited market opportunities	8	12.5%
Limited institutional support and policy frameworks	34	53.1%
High labour demands	20	31.3%
Limited access to credits	17	26.6%
Low awareness of climate change adaptation	27	42.2%
High risk of crop failure	45	70.3%
Inadequate extension services on climate resilience	21	32.8%



**Figure 4:10: Barriers encountered in adapting to rainfall changes**

Besides, there are still challenges in the practices of soil conservation and trials of institutional policy strategies which were seen as been less effective due to limitations of implementation and inadequate support. Therefore, the perceived effectiveness had indication of the importance of continuous innovation and adaptive production and management practices provided under local conditions and the needs of farmers.

The majority (79.7%) cited limited access to climate information as a barrier, hindering informed decision-making and adaptive planning. More so, high costs of resources and adoption (62.5%) pose financial barriers, limiting farmers' ability to invest in climate-resilient technologies and practices. A large proportion of farmers also reported inadequate irrigation infrastructure (71.9%) and limited institutional support (53.1%) to have hindered effective implementation of adaptation strategies, highlighting gaps in infrastructure development and policy frameworks.

It is therefore indicated that more than 70% responses show inadequate irrigation infrastructure, high risk of crop failure with even existing copying practices, high cost of

resources, limited technological support and institutional policy frameworks as the prominent challenges.

#### **4.10. Recommendations for Enhancing Adaptation to Changing Rainfall Patterns**

From the challenges faced as indicated above, different recommendations were as well suggested by those who had encountered them or seen how best they could be supported to adapt to the changing rainfall patterns that has negatively affected agricultural productivity in the region.

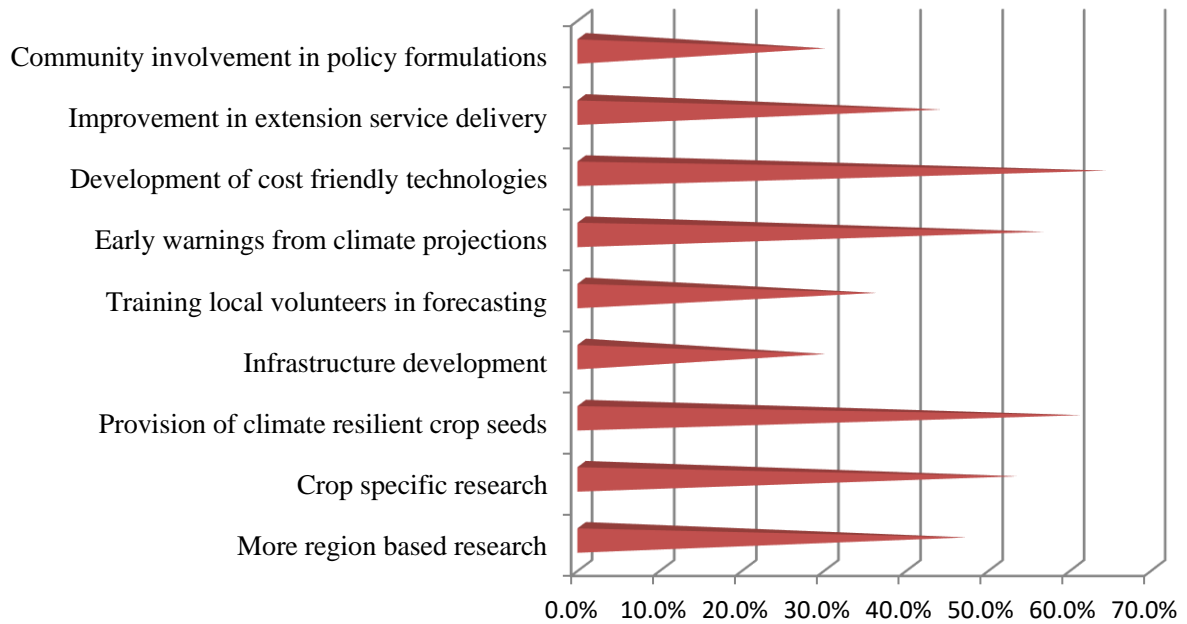
Different fractions of the respondents gave out their thoughts in what could be done to improve adaptation to variability in rainfall patterns and enhance agricultural resilience and these were compiled in the following table. These suggestions highlighted key areas where interventions and support were most needed in order to mitigate the effects of climate variability on crop production.

**Table 4:10; Recommendations for Enhancing Adaptation to Changing Rainfall Patterns**

<b>Recommendation</b>	<b>No. Of responses</b>	<b>% of response</b>
More region-based research	30	46.9%
Crop specific research	34	53.1%
Provision of climate resilient crop seeds	39	60.9%
Infrastructure development	19	29.7%
Training local volunteers in forecasting	23	35.9%
Early warnings from climate projections	36	56.3%
Development of cost friendly technologies	41	64.1%
Improvement in extension service delivery	28	43.8%
Community involvement in policy formulations	19	29.7%

A large proportion of farmers suggested development of cost friendly technologies, provision of climate resilient crop seeds and early warnings from climate projections to help enhance their resilience to rainfall variability.

### Farmers recommendations for enhancing adaptation



**Figure 4:11; Farmers recommendations**

The respondent farmers gave some recommendations aimed at strengthening the efforts to adapt to the impacts of climate variability. Of these included suggestions for research that is based on specific regions and particular crop plants to provide comprehensive solutions to address local climate challenges. Additionally, a significant fraction of the farmers recommended development of cost-friendly technologies and infrastructure improvement for enhancing adaptive capacity and resource efficiency in crop production.

Suggestions for community involvement in policy formulation and training in climate forecasting emphasized participatory approaches to resilience-building and knowledge sharing as it would fully incorporate collaboration, presenting interconnected challenges and opportunities in adapting to changing rainfall patterns through the integration of local knowledge with scientific insights, fostering innovation and addressing systemic barriers to build climate-resilient agricultural systems.

## **CHAPTER FIVE:**

### **5. CONCLUSIONS AND RECOMMENDATIONS**

#### **5.1. Conclusions**

Farmers in Paya experienced notable challenges due to climate variability exhibiting in form of irregular rainfall distribution, changes in intensity, frequency and duration. These changes have had detrimental effects on crop yields, soil health and general agricultural productivity especially in the field of crop production.

There has been adoption of various adaptation practices, including crop diversification, use of drought-resistant varieties, rainwater harvesting and adjustment of planting schedules which were important for mitigating the adverse impacts of climate variability and enhancing resilience in crop production systems.

While some adaptation strategies are considered effective, such as changing planting systems using drought-resistant varieties, soil conservation, and irrigation on a small scale, challenges such as limited availability of climate data, high cost and inadequate infrastructure remain major obstacles to successful implementation.

Farmers suggest increased research and development focused on region-specific and crop-specific needs, provision of climate-resilient seeds, infrastructure development and community involvement in policy formulation for enhancing adaptive capacity and sustainability in agriculture.

Strengthening community engagement, improving access to technological innovations and enhancing extension services are pivotal in creating resilience against climate change impacts and fostering sustainable agriculture practices.

#### **5.2. Recommendations**

In the context of the findings of this study, there is need to;

Allocate resources for region-specific and crop-specific research to understand the local climate dynamics, identify resilient agricultural practices and develop suitable technologies

that allow enhanced resilience to climate change which presents itself in form of changes in rainfall pattern.

There is also need to facilitate the availability and adoption of climate-resilient crop varieties that can withstand erratic rainfall patterns and associated stresses. Furthermore, improvement of irrigation infrastructure, water management systems and soil conservation practices to enhance water-use efficiency and soil health under changing climate conditions are needed for the same cause.

Strengthening extension services to provide timely climate information, training on adaptive practices and technical support to farmers, empowering them to make informed decisions can be essential besides implementation of supportive policies, incentives and regulatory frameworks that promote sustainable agricultural practices, resilience-building measures and climate-smart innovations.

Develop mechanisms to monitor and evaluate the effectiveness of these strategies to raise awareness of the impacts of climate change and ensure community engagement and continuous education on intervention, decision-making on community-led projects for adaptation and mitigation.

Finally, community engagement is needed to combine scientific knowledge with local strategies to provide actionable strategies in the locality to build climate adaptation capacity in the face of circumstantial change.

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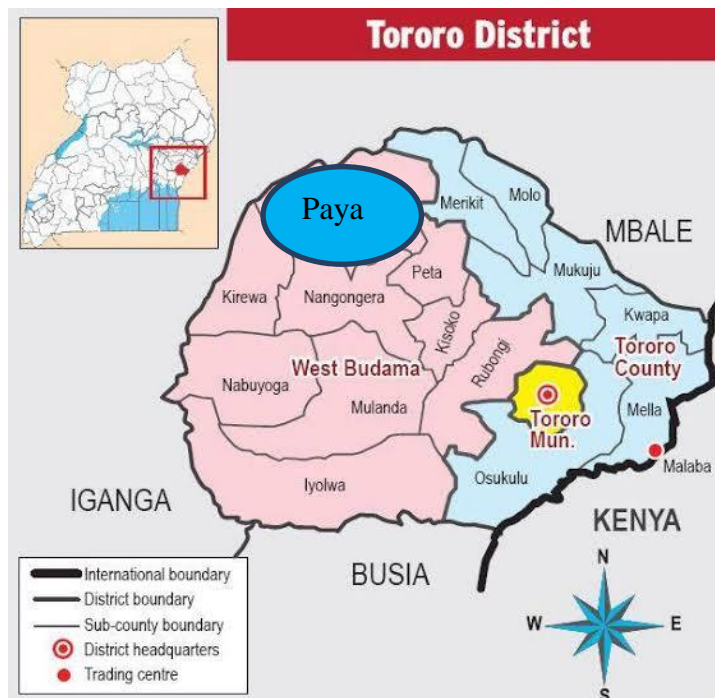
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## APPENDICES

**Appendix 1: Map of Uganda showing the location of Tororo**



**Appendix 2: Map of Tororo district showing the counties and sub counties**



### Appendix 3: Budget estimate for the research

S.NO	ITEM	COST (UG. SHS)
1	Transport	60,000=
2	Printing data collection materials	10,000=
3	Report printing and binding	45,000=
4	Participants benefits	70,000=
5	Miscellaneous	15,000=
6	Total	200,000=

### Appendix 4: Work plan for the research

S.NO	WEEK/DATE	ACTIVITY
1	5 <sup>th</sup> April – 11 <sup>th</sup> April, 2024	Preparation of data collection tools and materials
2	12 <sup>th</sup> April – 20 <sup>th</sup> April, 2024	Data collection
3	20 <sup>th</sup> April – 21 <sup>st</sup> April, 2024	Analysis of data
4	22 <sup>nd</sup> April – 24 <sup>th</sup> , April 2024	Interpretation of data
5	July, 2024	Preparing report draft
6	Sept, 2024	Report final copy for submission

## Appendix 5: Questionnaire

Dear respondent,

Greetings! I extend a warm welcome to you as a valued contributor to the assessment of adaptation strategies in mitigating the impact of changing rainfall patterns in Paya Sub-County, Tororo, Uganda. Your insights and experiences are crucial in comprehensively understanding the current landscape of adaptation efforts within the community. By participating in this questionnaire, you play an integral role in identifying effective strategies, highlighting challenges and outlining opportunities for enhancing resilience in the face of climate variability. Thank you for your time and valuable input. Please answer the following questions to the best of your knowledge and experience.

### Section 1: Demographic Information

(Tick appropriate)

**Age:**

Under 20 years

20-30 years

31-40 years

41-50 years

Over 50 years

**Gender:**

Male

Female

**Education Level:**

None (no formal education)

Primary education

Secondary education

Tertiary education

**Years of Farming Experience:**

Less than 5 years

5-10 years

11-15 years

16-20 years

More than 20 years

**Section 2: Rainfall Patterns and Crop Impact**

**How would you describe the changes in rainfall patterns over the past years in Paya?**

Increase in rainfall

Decrease in rainfall

Irregular rainfall distribution

Change in intensity

Change in frequency

Change in duration

Change in the spread

Unsure

**Have you observed any impact of changing rainfall patterns on crop growth, yield and production process in Paya? If yes, please tick in the boxes all that apply.**

- Reduced crop yields
- Changes in crop growth cycles
- Drought stress:
- Waterlogging:
- Soil erosion:
- Nutrient leaching:
- Shift in growing seasons:
- Increased pest and disease pressure:
- Changes in crop water requirements:
- Changes in water quality and availability for irrigation
- Increased risk of crop failure

Any other, please specify.

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**Section 3: Adaptation Strategies**

**What adaptation strategies have you employed to mitigate the impacts of changing rainfall patterns on crop production? (Check/tick all that apply)**

- Crop diversification

- Use of drought-resistant crop varieties
- Rainwater harvesting
- Irrigation systems
- Adjusting planting and harvesting schedules
- Soil conservation practices
- Adopt proper crop spacing
- Fertilizer application
- Apply moisture conserving practices
- Crop substitution
- Adopt institutional policies
- Other (please specify).....
- .....
- .....

**How effective do you perceive these adaptation strategies in reducing the negative impacts of changing rainfall patterns on crops?**

**Tick/Select in the box for each strategy applied under the following descriptions;**

**Very effective:** The strategy has exceeded expectations and achieved outstanding results.

**Effective:** The strategy has met its goals and objectives and has been successful in its implementation.

**Somewhat Effective:** The strategy has shown some positive results, but has also encountered some challenges and limitations.

**Less Effective:** The strategy has had limited impact and has not achieved its intended goals and objectives.

**Ineffective:** The strategy has failed to produce the desired results and has been unsuccessful in its implementation.

<b>Strategy</b>	<b>Very effective</b>	<b>Effective</b>	<b>Somewhat effective</b>	<b>Less effective</b>	<b>Ineffective</b>
Crop diversification					
Drought tolerant varieties					
Rainwater harvesting					
Irrigation					
Adjusting planting dates					
Soil conservation					
Crop spacing					
Fertilizer application					
Moisture conservation					
Crop substitution					
Adopt Institutional policies					
Practicing drainage					

#### **Section 4: Challenges in Implementation**

What challenges have you encountered in implementing and sustaining adaptation strategies in response to changing rainfall patterns?

- Limited access to climate information and forecasting tools
- High upfront costs and limited financial resources for implementing adaptation strategies

- Limited technological support and early warning systems
- Limited availability of climate-resilient crop varieties
- Inadequate irrigation infrastructure and water management systems
- Soil degradation and nutrient depletion due to increased erosion and changed rainfall patterns
- Increased pest and disease pressure due to changing environmental conditions
- Limited access to markets and economic opportunities for climate-resilient products
- Limited institutional support and policy frameworks for climate change adaptation
- High labor demands and limited labor availability for implementing adaptation strategies
- Limited access to credit and insurance for climate-related risks
- Limited awareness and understanding of climate change impacts and adaptation options
- High risk of crop failure and livestock mortality due to changing rainfall patterns
- Limited availability of climate-resilient agricultural extension services and advisory support
- Any other; please specify

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**Section 5: Recommendations**

Based on your experience, what would you recommend to the improve adaptation to changing rainfall patterns and enhance resilience in agricultural practices in Paya?

- More region based research

- Crop specific research
- Provision of climate resilient crop seeds
- Infrastructure development
- Training local volunteers to engage in forecasting
- Early warning from climate projections
- Development of cost friendly technologies
- Extension services to be rendered in regard to shifts in precipitation patterns
- Community involvement in planning, policy formulation and implementation

Do you have any additional information on adaptation to changing rainfall patterns in Paya?  
Please include here.

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Thank you for participating in this survey. Your insights are valuable for this study.