

**MAKERERE**



**UNIVERSITY**

**CLIMATE CHANGE IMPACTS ON FOOD AVAILABILITY AND COPING  
RESPONSES IN PALLISA DISTRICT**

**BY**

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**2019/HD02/27397U**

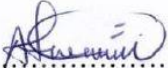
**BSc. BCB [MAK]**

**A DISSERTATION SUBMITTED TO THE DIRECTORATE OF GRADUATE  
TRAINING (DGT) IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE  
AWARD OF THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENT AND  
NATURAL RESOURCES MANAGEMENT OF MAKERERE UNIVERSITY**

**OCTOBER, 2025**

## DECLARATION

I, **Hilda Prima Atwiine**, hereby declare that all the contents in this dissertation are original and authentic, produced by me, unless otherwise stated, and that this dissertation has never been submitted to any other university or academic institution for an award or any educational qualification.

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## APPROVAL

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## **ACKNOWLEDGEMENTS**

I want to extend my sincere appreciation to my supervisors, Professors David Mfitumukiza and Revocatus Twinomuhangi, for their invaluable guidance and unwavering support throughout my research journey. Their insights and encouragement were instrumental in the completion of this work. I extend my gratitude to my colleagues for their continuous encouragement and the fruitful technical discussions.

## **DEDICATION**

This thesis is dedicated to my beloved mother and siblings, whose endless love, unwavering prayers, and support have been my constant source of strength. I also dedicate this work to my dear Aunt Dr. Edrida Muheki for her profound inspiration and belief in my potential.

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## LIST ACRONYMS

AGRA	Alliance for a Green Revolution in Africa
ANOVA	Analysis of Variance
DF	Degrees of Freedom
FAO	Food and Agriculture Organization of the United Nations
FEWSNET	Famine Early Warning systems Network
FGDs	Focus Group Discussions
IPCC	Intergovernmental Panel on Climate Change
ISFM	Integrated soil fertility management
KII	Key Informant Interviews
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MSS	Mean Sum of Squares
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organization
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
OWC	Operation Wealth Creation
SACCO	Savings and Credit Cooperative Organization
SMEs	Small and Medium enterprises.
SS	Sum of Squares
SSA	Sub Saharan Africa
UBOS	Uganda Bureau of statistics
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WFP	World Food Programme

## ABSTRACT

Climate change has been reported to undermine agricultural productivity, especially in climate-sensitive regions like Sub-Saharan Africa, Uganda inclusive, affecting food availability especially and more especially the semi-arid areas of Uganda. This study was conducted to investigate how climate change affects food availability and overall household resilience and food security in Pallisa District, Uganda. The specific objectives were to: i) examine the trends in climate change (rainfall and temperature) from 1990 to 2021 in Pallisa District, ii) examine the perceived impacts from climate change on food availability, and iii) assess the coping responses to climate change impacts on food availability. A cross-sectional survey research design was used to collect data on changes in temperature and rainfall, and the related impacts on food availability and coping strategies. Quantitative data was collected from a sample of 375 household respondents using a survey semi-structured questionnaire. Qualitative data was obtained through Focus Group Discussions and Key Informant Interviews. The study found that rainfall and temperature varied significantly over the study period of thirty-one years from 1990 to 2020. The most common impacts of climate change on food availability were increased temperature (59.8%), pests and diseases (37.8%), shift in rainfall season (36.6%) and delayed onset of rains (31.7%), among other impacts which results into low crop yields. The notable responses included; early planting (80%), crop diversification (60.4%), adoption of early maturing crop varieties (49.1%) and planting resistant crop varieties (38.6%). The food chain is highly vulnerable to climate change which threatens food security especially in the low-income communities and it is therefore recommended that government and development partners help in building equitable food systems to sustain livelihoods and ensuring food security for future generations.

### **Key words**

Climate change, food availability, food security, rainfall and temperature trends, coping responses, Pallisa District, Uganda.

## CHAPTER ONE: INTRODUCTION

### 1.1 Background

Globally, food availability remains a critical challenge with climate change being a paramount factor leading to hundreds of millions starving (FAO et al., 2021). According to the (FAO, et al., 2023) an estimated 735 million people faced chronic hunger in 2022, an increase of 122 million compared to 2019, prior to the COVID-19 pandemic. Sub Saharan Africa remains the most food-insecure region, where one in five people (approximately 20%) experience hunger more than twice the global average of 9%.

Food availability is the degree to which food is consistently physically obtainable in desired quantities, shaped by the production, distribution, and exchange patterns of food (Rivera Ferre, 2014; Carson & Boege, 2020). Food availability as one of the core dimensions of food security is largely influenced by production, stock levels and the net trade (FAO, 2008; Rivera Ferre, 2014). Climate change may dictate food availability by influencing rainfall levels and related parameters like temperature and pest infestation, which destabilize the production yields (El Bilali et al., 2020).

In Uganda, agriculture supports approximately 70% of the population and contributes about 24% to GDP (UBOS, 2024). Yet nearly 29% of Ugandans are food-insecure, and over 48% experience moderate food insecurity, (FAO et al., 2023). UBOS and ICF, 2023) further reveals that only 45% of households enjoy consistent year-round food availability, with the eastern and northeastern regions including Bukedi and Karamoja recording the highest rates of food shortages.

The impacts of climate change on food production can, among other ways, manifest through; increased frequency and severity of floods and droughts, increased severity of pests and diseases, livestock mortality, crop failure and poor yields (Morton, 2007; Conway, 2008; Mubiru et al., 2018). In Uganda, the gravity of this challenge is underscored by estimates suggesting that approximately 34% of crop production losses are directly attributable to alterations in climate factors like rainfall and temperature (Diane Nabikolo, 2014).

Despite the evident national impacts, the assessment of climate change trends for localized parameters including rainfall and temperature have received insufficient attention, hindering the

development of area specific knowledge essential for combating the associated climate change impacts effectively. Studies consistently demonstrate that even slight changes in temperature and rainfall can profoundly affect the production of staple food crops such as maize, rice and wheat among others (Morton, 2007; Tanure et al., 2020; Yengoh & Ardö, 2020; Gabiri et al., 2020). The interlinkages among food production (yields), transportation and distribution are fundamental in defining overall food availability and accessibility, particularly for populations residing far from primary production areas. Even in scenarios of robust yields, climate change can severely disrupt the food supply and distribution chain leading to delays and outright failures in delivering food to specific locations. For instance, heavy rainfall accompanied by flooding can sever roads and communication networks vital for connecting production areas to the markets, resulting in delayed distribution and subsequent food unavailability (Janssens et al., 2020; Chiffolleau et al., 2020). Furthermore, temperature fluctuations heighten risks of food perishability undermining its availability, at both market and household levels (Parfitt et al., 2010). While climate change challenges and food insecurity have been reported in parts of Eastern Uganda, notably the Karamoja sub-region (Levine et al., 2011; Egeru et al., 2019) most existing studies on food security have predominately focused on singular component, production, thereby sidelining a comprehensive assessment of food availability and accessibility across the full value chain. Tackling the impacts of climate change on the multifaceted dimensions of food availability is critical because it enhances the efficiency of food distribution and ultimately strengthens food security for communities otherwise highly vulnerable to climatic shocks. Furthermore, assessment of climate change impacts across the food values chain, provides the necessary evidence to design effective and targeted adaptation strategies that enhance resilience throughout the entire food system, ensuring that interventions are equitable and inclusive (Thompson et al., 2010). Without this broad perspective policies risk overlooking key bottlenecks and indirect impacts, hence limiting their effectiveness in safeguarding food security under a changing climate.

Climate related risks to foods systems are particularly pronounced in the Sub-Saharan Africa, manifesting as reduced agricultural yields, exacerbated water scarcity, and increased competition for water resources due to reduced rainfall and higher evapotranspiration, severely impacting irrigation and livestock (IPCC, 2022). While coping strategies such as livelihood diversification, through agroforestry and livestock integration have been reported, (Thornton et al. (2014) there remains limited data to evaluate the long-term effectiveness of these strategies and

underrepresentation of gender dimensions in food security coping responses. Although studies such as Thornton et al. (2014) assessed adaptation strategies to food security and climate change, their primary focus was on the adaptive livelihood strategies at household level. This limits our current understanding of how communities cope disruptions in distribution, trade and other critical components of the broader food chain amidst climate change. Therefore, this study was designed to specifically assess the impacts of climate change on household food availability in Pallisa District by examining trends in rainfall and temperature, the perceived impacts on food production, processing, distribution and exchanges, and the coping responses households employ to sustain availability. The availability of information on location specific climate adaptation and coping strategies employed by farming households to specifically ensure food availability is paramount for enhancing the strategic design of climate change interventions (Mulinde et al., 2019). However, a critical gap persists as there are currently no comprehensive studies on the intertwined issues of climate change impacts and food availability in the Bukedi sub-region and Pallisa in particular. This is particularly concerning given that Bukedi sub-region is highly food insecure and ranks among the top in multidimensional poverty rates, exceeding the national average (UNICEF, 2020). Furthermore, the district faces a significant demographic challenge, with a high annual population growth rate of 4.26%, (UBOS, 2017) which intensifies demand for already climate-vulnerable food resources and places additional strain on agricultural land and natural resources, exacerbating food availability. Addressing this fundamental knowledge gap will be vital in guiding government and development partners to formulate context-specific interventions that stabilize food supply and distribution systems in climate-stressed areas such as Pallisa District.

## **1.2 Problem statement**

Climate change has been reported to affect food production, distribution, and trade especially in the semi-arid areas of Uganda including the cattle corridor (Nimusiima et al., 2018; Twongyirwe et al., 2019). The rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events have already begun to undermine agricultural productivity, especially in climate-sensitive regions like Sub-Saharan Africa and South Asia (IPCC, 2022; FAO, 2023). These climatic shocks are not only reducing crop yields but also affecting the reliability of food supply chains, storage conditions, and transport infrastructure (WFP, 2022). In addition to production losses, climate change-induced disruptions in food trade and transportation have led to

increased food prices and reduced market access, particularly in developing countries where infrastructure is limited (Garnett et al., 2020). For instance, flood-damaged roads, port disruptions, and rising fuel costs have all contributed to delays in food delivery and losses in perishable goods (Porter et al., 2019). Likewise, inadequate and climate-vulnerable food storage systems expose stored food to spoilage, contamination, and post-harvest losses, exacerbating the risk of food insecurity (Mwambi et al., 2021).

Despite increasing recognition of such issues, research often focuses on singular components of the food system, such as production or market access, without sufficiently examining the full value chain and its vulnerabilities to climate change (e.g., Bagamba et al., 2012; Bott, 2013; Tesfay, 2014; Van et al., 2015; Karki et al., 2016; Mfitumukiza et al., 2017; Derr et al., 2018; Teklewold et al., 2018). This creates a critical knowledge gap in understanding how the various components of food availability such as production, trade, transportation, distribution, and storage interact under changing climatic conditions. In fact, studies in eastern Uganda have mainly focused on the Karamoja sub region, excluding other areas such as Bukedi sub region inclusive of Pallisa district. The Bukedi sub region is highly food insecure and ranks top in the multidimensional poverty rates, higher than the national average (UNICEF, 2020). Addressing this gap is essential for informing holistic strategies that enhance food security in a different area.

Therefore, there is a need to investigate how climate change is affecting each segment of the food supply chain and to identify integrated responses that can sustain food availability across diverse contexts. Such a study is hence timely and vital for guiding adaptation strategies and ensuring equitable access to food amid an increasingly uncertain climate future.

## **1.3 Objectives**

### **1.3.1 Main objective**

To investigate how climate change impacts food availability in Pallisa District to contribute to household resilience and food security as required by Sustainable Development Goals 2 and 13 on zero hunger and climate action respectively.

### **1.3.2 Specific objectives**

The specific objectives were to:

- i. Examine the trends in climate change (rainfall and temperature) from 1990 to 2021 in Pallisa District
- ii. Examine the perceived impacts from climate change on food availability in Pallisa District
- iii. Assess the coping responses to climate change impacts on food availability in Pallisa District

### **1.4 Research questions**

Questions for objective one

1. How has rainfall changed in the last thirty (31) years within Pallisa District?
2. How has temperature changed in the last thirty (31) years within Pallisa District?

Questions for objective two

1. What impacts are resulting from changes in rainfall and temperature in Pallisa district?
2. How do the climate change related impacts experienced in Pallisa District affect food production, processing, distribution and exchanges?

Questions for objective 3

1. How have households in Pallisa District sustained food availability in the face of climate change?

### **1.5 Significance of the study**

In order to design effective climate change adaptation plans that increase the resilience of communities in marginal areas, there is a need to recognize sensitivities to different impacts as well as the heterogeneity of agro-ecological zones (Taylor et al., 2014). These marginal areas are often associated with diverse impacts such as drought and floods among others (Majaliwa & Isubikalu, 2010; Mfitumukiza et al., 2017). This leads to the adoption of various interventions that are aimed at fortifying the adaptive and absorptive capacities of these communities to such impacts. In Uganda households have undertaken initiatives to ensure availability of safe, enough and nutritious food at all times (Wekesa et al., 2018). However, more studies that provide updated information on the current trends of climate change and adaptation practices to ensure food

availability across different specific locations are urgently needed. Despite its high vulnerability to climate change impacts, data on the climate change and its impacts on food availability is limited. This study therefore purposively targeted Pallisa district in order to contribute to the body of existing knowledge on the nexus between climate change and food availability.

## **1.6 Scope of the Study**

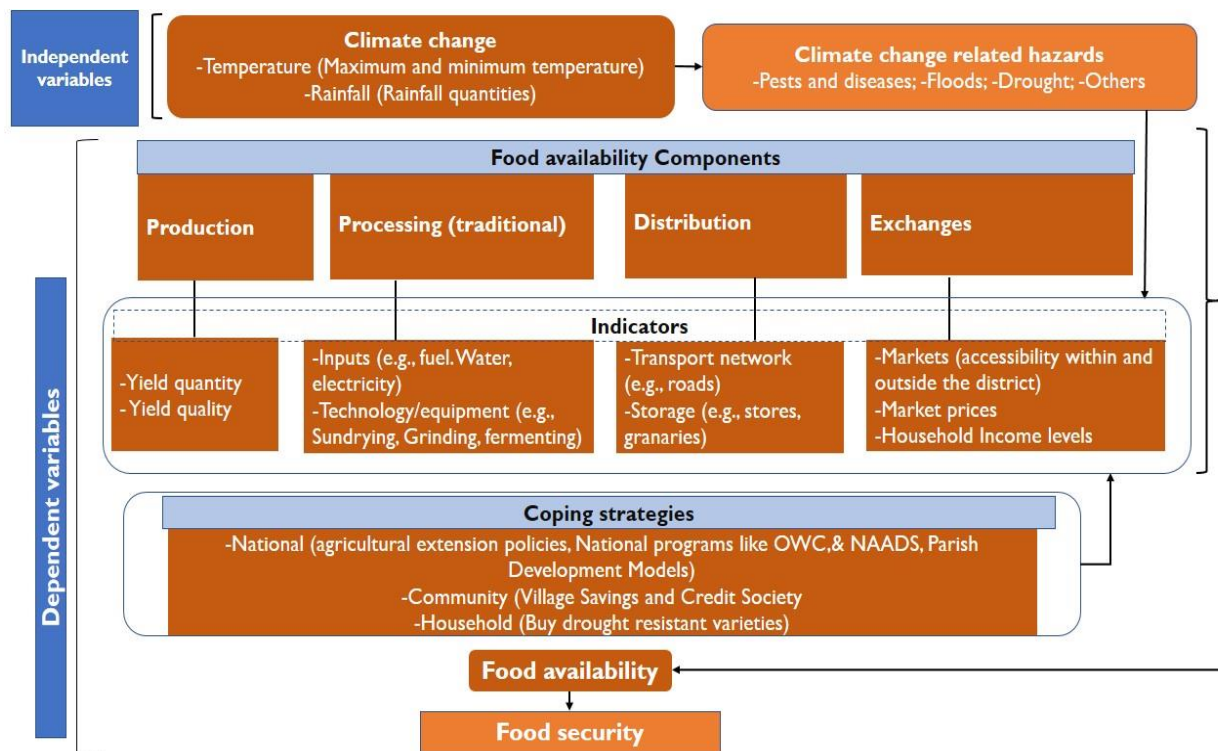
This study is focused on Pallisa District that lies within Bukedi Sub-region, in the cattle corridor area in Uganda. The choice of Pallisa District is because it's one of the poorest districts and it lies within the cattle corridor and Bukedi sub-region (Chombo et al., 2018). Focus will be on rainfall and temperature as the climate and weather elements associated with the major impacts affecting food availability. The study will be centered on food availability components including production, distribution, and exchanges and how they are impacted by climate change. Lastly, it will document the coping responses employed by households to sustain food availability.

## **1.7 Conceptual Framework**

This study is premised on the general understanding that climate change impacts on food availability (Rivera Ferre, 2014; Firdaus et al., 2019). Notably, climate change including alteration in trends of temperature as well as quantities of rainfall results into climate related hazards including; drought, floods, pests and diseases among others. Occurrence of climate related hazards (e.g., drought, pests and diseases) influence food availability components of; production, processing, distribution and exchanges (Iizumi & Ramankutty, 2015; Kinda & Badolo, 2019). At production level, occurrence of climate change related impacts such as drought undermine crop yields. Meanwhile at processing level, climate related impacts can undermine food processing (Mira de Orduña, 2010). Contextualizing this to Uganda, climate change can impact on food processing activities including; sun drying, grinding and fermentation (MAAIF, 2003). At distribution level, climate change impacts food transportation networks e.g., roads through floods among others. Additionally, climate change can affect food storage through increased pests and moisture content increasing food spoilage Ministry of Agriculture Animal Industry and Fisheries (MAAIF, 2003). Regarding exchanges, climate change affects household income levels through, among others, limiting alternative sources of income (Mbow et al., 2019). This undermines purchasing power of households and circulations of money to facilitate food distribution.

Similarly, climate change can result into increase in the market price of a food product by causing low yields on farm, increasing transport costs through damaging road networks by flooding, limiting accessibility by the households.

Households may implement area specific coping responses to sustain food availability. These coping responses are implemented to address the different components of food availability. Also, the coping responses can be implemented at different levels including; national, community and household level. National level interventions include policies and programs that enhanced household food availability. Programs like the National Agricultural Advisory Services (NAADS), Operation Wealth Creation (OWC) have a potential to enhance food availability. At community level, interventions like village savings and credit societies can enhance exchanges through loans increasing food availability. Interventions at household level can as well be implemented to enhance food availability. The end result is enhanced food security within households. This is illustrated in Figure 1.



**Figure 1:** Relationship between climate change and food availability



## CHAPTER TWO: LITERATURE REVIEW

### 2.1 Climate change and its impacts in Sub-Saharan Africa

Between 1886 and 2012, global average temperatures have risen by 0.85°C and this is reflected across all regions of Sub-Saharan Africa (SSA); and further increases of about 1.5°C by 2050 are almost certain (AGRA, 2014). Increased frequency and severity of extreme climatic events (severe storms, flooding, droughts, etc.) are very likely (AGRA, 2014; Eisenack & Stecker, 2012). Other important changes are also affecting the agricultural environment and will certainly continue to 2050 unless successfully addressed (Gizaw & Gan, 2017; FAO, 2017). For example, declining soil fertility, reduced farm size, and rural to urban migration all present challenges to achieving food security (AGRA, 2014). Early decades of the twenty-first century will see a moderate global warming of 1-2°C, resulting in reduced crop yields in seasonally dry and tropical regions, while crop and pasture yields in temperate regions may benefit. Further warming in the second half of the century will negatively affect all regions, although agriculture in many developing countries in semi-tropical and tropical regions will bear the brunt of the effects (Ringler et al., 2010; Caserini, 2017). Increased frequency and severity of extreme climate events, such as more heat stress, droughts and flooding, is expected in coming decades due to climate change. It will increase negative impacts on agriculture, forestry and fisheries in all regions (UNFCCC, 2007; Vermeulen et al., 2012; El Bilali et al., 2020). In particular, it will modify the risks of fires, and pest and pathogen outbreaks, with negative consequences for food availability (Convention & Change, 2016). This will significantly undermine food security. Most of these catastrophic events are projected with sub-Saharan Africa being “hit-hard” (Okumu, 2013; FAO, 2014).

Climate change affects average temperatures and temperature extremes; timing and geographical patterns of precipitation; snowmelt, runoff, evaporation, and soil moisture; the frequency of disturbances, such as drought, insect and disease outbreaks, severe storms, and forest fires; atmospheric composition and air quality; and patterns of human settlement and land use change (El Bilali et al., 2020). Thus, climate change leads to myriad direct and indirect effects. Climate is a primary factor for agriculture productivity, such that any environmental change affects plant and animal production and thus food availability (FAO, 2014). Climate variations and changes can have significant impacts on agricultural production, forcing farmers to adopt new practices in response to altered conditions (AGRA, 2014). The temporal and spatial variations in climate have

a direct influence on the variability of available soil moisture (Herceg et al., 2019; Erler et al., 2019). Higher temperatures, changes in precipitation, and increased climate variability affects agricultural production, processing and access to food supply points (Rivera Ferre, 2014; Firdaus et al., 2019; Kinda & Badolo, 2019).

Climate change has resulted in increased temperatures, which increase transpiration and evapotranspiration rate causing severe water stress as plants lose a lot of water and soil moisture is depleted (Ali & Erenstein, 2017; Ubisi et al., 2017). The effect of increased temperature depends on the crop's optimal temperature requirements for growth and reproduction such that if warming exceeds a crop's optimum temperature, yield declines (Kikoyo & Nobert, 2016; Okonya et al., 2013). Reduced soil moisture decreases available water for irrigation as water level from water sources decrease, and it becomes more difficult to meet plant water demand even by irrigation (Shongwe et al., 2013). During droughts, plant roots are underdeveloped and unable to absorb nutrients and mineral from the soil (Shongwe *et al.*, 2014). Reduced soil moisture decreases the amount of dissolved nutrients, increase concentration of nutrients making them toxic, and increases salinization.

On the other hand, droughts reduce soil fertility by reducing the organic component of the soil as the amount of crop residues is reduced. Leaching of soil nutrients occur during floods and high intensity rainfall. This has a negative impact on plant growth as plants suffer from nutrients deficiency syndrome. High rainfall intensity is one major cause of soil erosion as it removes the top nutritious soils and reduce nutrients availability to plants, reducing productivity (Mugagga et al., 2010; Seager et al., 2010). Climate change alters the distribution, incidence, intensity of pests, diseases and invasion of alien species (Aalst et al., 2014). High temperatures coupled with wet conditions create new niches and favors growth of pests and pathogenic organisms (Longden et al., 2015; Teka et al., 2012). Droughts and floods kill animals that are used by small scale farmers for ploughing, thereby leaving them with no choice, but to hire tractors. However, most rural households do not afford such services because of their poor financial background. Planted areas are therefore reduced and food insecurity increases forcing them to rely on food aid (Okello, 2014; USAID, 2011).

## 2.2 Trends in climate change

Climate change is recognized as serious global challenges of the 21st century, with increments in global surface temperatures and changing rainfall patterns. The Intergovernmental Panel on Climate Change confirms that global surface temperature increased by approximately 1.1°C above pre-industrial levels by 2021, attributed largely to greenhouse gas emissions from human activities (IPCC, 2021). Such warming trends have influenced both regional and global climate systems, including precipitation patterns, extreme weather events, and seasonal variability.

Globally, there has been a consistent rise in temperatures over the last century, with the most significant warming occurring since the 1980s. According to NASA (2023), the last decade has been the warmest on record. Temperature projections under various greenhouse gas scenarios suggest further increments by 1.5°C to 4.4°C by the end of the 21st century (IPCC, 2021). However, regional based assessments have indicated that warming is more pronounced in higher latitudes and interior continental regions. For example, Serdeczny et al. (2017) projected Africa to experience warming above the global average, with serious implications for food security and water resources.

Climate change has also affected rainfall trends, with some regions experiencing more intense rainfall while others face increasing dryness. The World Meteorological Organization (WMO, 2022) reported that precipitation extremes continue to become frequent and intense due to higher evaporation rates from warmer temperatures. In East Africa, rainfall variability has increased, contributing to more frequent floods and droughts (Gebrechorkos et al., 2020). Meanwhile, southern Africa has experienced declining rainfall trends, especially during critical agricultural seasons, leading to prolonged drought conditions.

Future projections in rainfall indicate significant shifts in the hydrological cycle, with wet regions likely to become wetter as dry areas get drier (IPCC, 2021). Regional climate models suggest that East Africa may experience an increase in short, intense rainfall events but with less reliable seasonal rainfall (Endris et al., 2019). This unpredictability complicates water resource planning and agricultural scheduling. In contrary, projections for the Sahel region show potential for both increased rainfall and enhanced variability, increasing the risk of extreme hydrological events (Biasutti, 2019).

Such observed and projected variations in temperature and rainfall have far-reaching implications for agriculture especially food availability, water resources, and human wellbeing. Continued warming and variability in rainfall demand urgent adaptation strategies and mitigation efforts to manage climate risks. However, area specific knowledge is still limited in poverty and food insecure areas such as the Bukedi sub-region to enhance household preparedness, coping and adaptation capacity.

### **2.3 Impacts of climate change on food security**

The majority of the people in Sub-Sahara Africa depend on agriculture as their main source of livelihoods and dietary needs; and a population rise in this region translates to increased consumption rates and high demand for the food respectively (United Nations, 2015a). Based on observed population of population growth in Sub-Saharan countries like Uganda, Nigeria, and Tanzania; it is estimated that agricultural production will need to increase six-folds by 2050 in order to be able to meet the growing food demands of the globally growing population (Faurès et al., 2013; United Nations, 2015a). The agricultural sector in the region will need to be transformed to meet the people's food demands and at the same time, the countries' exports required for economic development and poverty alleviation. However, Sub-Sahara Africa is highly vulnerable to the impacts of climate change and variability (Thornton *et al.*, 2014). Agriculture is mainly rain-fed and natural resources dependent and thus often affected by impacts of climate change and extreme weather events such as drought, hailstorms and floods (Niang et al., 2014; Shiferaw et al., 2014). This is exacerbated by high poverty levels that make it impossible for farmers to invest in climate-proof agriculture and diversify their economies to non-climate sensitive sectors (Niang et al., 2014). Responses to ensure farming households are able to ensure availability of food in the changing climate ought to be promoted (IPCC, 2013). Availability of adequate data on the location specific dynamics of climate change, impacts and coping responses ought is vital for guiding such responses (Faurès et al., 2013; Ngara, 2017).

In Uganda, the agricultural sector plays an important role in the economy and is the backbone of the country; owing to being the country's main source of exports such as coffee and contributes about 21% of the gross domestic product (UBOS, 2017). Climate change is already having tremendous impacts on agricultural activities in the country through reduced rainfall amounts, increased temperatures, frequent and prolonged droughts, increased crop and livestock pests and

diseases (FEWSNET, 2012; Nsubuga & Rautenbach, 2018). The observed temperature increases are affecting the production of major cash crops such as coffee and food crops like banana and cereals (maize and millet) which are major staples foods (Moore et al., 2012; Philip K. Thornton et al., 2014). This has resultant consequences on food availability and ultimately food security. Increased impacts of climate change on food production in Uganda and high population growth and expansion of agricultural activities into drier areas by farming and pastoral households in the country will certainly drastically increase the vulnerability of Ugandan local communities to crop failure and livestock as well as compromising food insecurity loss (Egeru *et al.*, 2016; Mayanja *et al.*, 2015). Unsustainable agricultural practices such as lowland rice farming in eastern parts of Uganda have been associated with drainage of wetlands and the release of methane emissions to the atmosphere (Ministry of Water and Environment, 2014). Therefore, there is a necessity for the agricultural sector in Uganda to adopt agricultural practices that support sustained food availability (Kikoyo & Nobert, 2016). This can be possible through understanding of the dynamics between climate change and food availability. Location specific scientific data is key in designing such strategies. Unfortunately, there is no such data for places like Pallisa District that lie within the cattle corridor that is highly vulnerable to climate change (Basalirwa, 2014; Stark, 2011).

#### **2.4 Household food availability and the sustainable development goals**

Household food availability refers to the quantity and diversity of food that a household can access through production, purchase, or transfers to meet dietary energy and nutrient needs (Jones et al., 2017). In many rural contexts, food availability depends on a mix of on-farm production, off-farm income, and market purchases, with variations influenced by agro-ecological conditions, market access, infrastructure, and seasonal patterns (Jones et al., 2017). Low agricultural productivity, limited income, and poor infrastructure often constrain household food supply, leading to seasonal shortages and heightened vulnerability to food insecurity (Alemu et al., 2020).

Insufficient household food availability has profound health and nutrition consequences. Studies across sub-Saharan Africa reveal that inadequate availability and low dietary diversity are associated with undernourishment, stunting, wasting, and higher infant mortality rates (Abegaz, 2023; Osei et al., 2023). Even when caloric needs are met, lack of dietary diversity can result in micronutrient deficiencies, particularly among children and pregnant women (Osei et al., 2023).

Improving both the quantity and diversity of available foods is therefore essential for achieving adequate nutrition and safeguarding public health.

Enhancing household food availability directly supports SDG 2 (Zero Hunger), which aims to end hunger, achieve food security, and promote sustainable agriculture (United Nations, 2015b). Adequate food availability also contributes to SDG 1 (No Poverty) by reducing the economic burden of hunger and malnutrition, SDG 3 (Good Health and Well-being) through improved nutrition outcomes, SDG 12 (Responsible Consumption and Production) by promoting sustainable food systems, and SDG 13 (Climate Action) when agricultural practices are environmentally sustainable (Omotehinse & Ako, 2022). Strengthening smallholder agricultural productivity, improving market access, and reducing post-harvest losses are key strategies emphasized in the literature to advance these interconnected goals (Omotehinse & Ako, 2022).

Despite these efforts, achieving SDG 2 by 2030 remains a challenge. Barriers include climate change, conflicts, economic inequality, and supply chain disruptions, which continue to threaten household food availability (Sustainable Earth Reviews, 2024). Policies to improve food availability must therefore be multi-sectoral, integrating agricultural innovation, market development, climate resilience, and social protection to ensure that food availability translates into equitable access and utilization.

## **2.5 Household food availability in Uganda and how it relates to climate change**

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as “the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC, 2007). The way IPCC defines vulnerability; it is a function of exposure, sensitivity and adaptive capacity. Exposure is defined as “the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure or economic, social or cultural assets in places and settings that could be adversely affected” (IPCC, 2014); “sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change” (IPCC, 2007); and adaptive capacity (also referred to as adaptability) is the ability or potential of a system to adjust to climate change, to take advantage of opportunities and cope with the negative consequences (IPCC, 2007).

Smallholder farmers in SSA are currently vulnerable to a wide range of stresses, and ‘vulnerability assessments’ of farming communities and their farming systems are complex undertakings that require multi-dimensional approaches (AGRA, 2014). They need to encompass environmental, social and economic spheres, as described by Malcomb et al., 2014, and incorporate such features as susceptibility, exposure and coping/adaptive capacities. Smallholder farmers live in pre-carious conditions and are intrinsically vulnerable to any shocks that affect their agricultural systems (Harvey et al., 2014). As in much of rural parts of Africa, the farmers live in rustic houses, lack electricity and running water, own few assets and rely on natural ecosystems for drinking water, firewood, wild foods and materials for household construction. Agriculture is the mainstay of farmer livelihoods, serving both as the primary source of household food and principal means of income generation. Consequently, the fate of these smallholders is closely interwoven with that of farming.

In their studies on Malagasy farmers, Harvey et al. (2014) found that they are particularly vulnerable to any reductions in crop productivity for a variety of reasons. First, the farmers cultivate very small parcels of land (less than 1 ha), dedicate most of their land to crop production for household consumption and obtain low crop yields, which are insufficient to meet household needs, let alone provide surplus for sale. McDowell (2012) as cited in: Harvey et al. (2014) since livelihoods of farmers depend directly on agriculture, they are often vulnerable to unexpected shock events that result in crop failure and subsequent fluctuations in food availability. This has a resultant effect on food/income insecurity due to constrained resources and an inability to respond quickly to environmental changes. Patently, because the fate of these smallholder farmers will determine the outcome of the global fight in reducing poverty and hunger and understanding their contextual situations and response to climatic shock events is a critical step in addressing the challenges of food insecurity.

## **2.6 Addressing food availability challenges in a changing climate**

Changes in temperatures affects crop and livestock production through proliferation of pests, diseases and weeds such as Africa army-worms (*Spodoptera exempta*) and Witch weed (*Striga sp*) among others (Midega et al., 2018; Rodenburg & Bastiaans, 2011). This undermines yields and limits amount of food to be distributed and thus impacts on food availability (Rivera Ferre, 2014; Firdaus et al., 2019).

Several interventions including climate smart agriculture have been implemented and have aimed at devising practices that support sustainable crop production intensification, minimizing the impact of climate change on crop productivity and food security of farmers while minimizing the amount of greenhouse gas emissions from farming activities (Faurès et al., 2013). Crop diversification involving the intercropping of different kinds of crops on the farm helps in maintaining soil fertility and reducing the spread of crop pests and diseases from one crop to another on the farm (FAO, 2017). In Kenya, an advanced form of intercropping called “*Push and Pull Technique*” that involves planting of different crops such as maize and beans in alternating rows on the farm is being hailed for effectively controlling army-fall worms, promoting food security and increasing incomes of farmers (Midega et al., 2018; Murage et al., 2015). Crop rotation involving practices of seasonally interchanging the type of crop grown on the farm is important for maintaining soil fertility and preventing soil erosion through crop roots that bind soil particles together (FAO, 2017). Planting of improved crop varieties that are both early maturing, drought and pest resistant is highly promoted among farmers in Uganda for minimizing crop failure and promoting adaptation to the impacts of climate variability in the country (Mitaru et al., 2006).

Integrated soil fertility management (ISFM) involving a combined use of practices that promote proper management of soil fertility including use of fertilizer, organic farming, use of improved germplasm and local knowledge of knowledge adapting these practices to the local climatic conditions to maximize crop productivity (Vanlauwe et al., 2015). Improved soil moisture conservation techniques such as mulching, terracing and contour planting serve doubles advantages of controlling soil erosion and maintaining soil fertility, soil temperature and soil water storage for plant uptake (Taylor et al., 2013). Soil mulching also helps in promoting the activities of soil microorganism that are useful in breaking down decaying plants and promote soil organic matter while at the sometime burrowing tunnels that ensure proper soil aeration and water infiltration (Mfitumukiza et al., 2017).

## **2.7 Coping to climate change impacts to enhance food availability among farmers**

Climate change is a big threat to food security, especially among smallholder farmers in developing regions who rely heavily on rain-fed agriculture. The rising temperatures, erratic rainfall, prolonged droughts, and extreme weather events negatively affect crop yields, food

production systems, and food availability (IPCC, 2022). The Food and Agriculture Organisation shows that farmers in Sub-Saharan Africa and other vulnerable regions are disproportionately affected due to limited adaptive capacity and reliance on traditional farming practices (FAO, 2021b).

Climate change impacts agriculture in a multidimensional way, influencing crop growth, pest outbreaks, soil fertility, and water availability. Schlenker & Lobell (2010) indicate that without adaptation, the performance of major crops like maize, wheat, and rice may decline significantly in tropical and subtropical regions resulting into reduced yields. For instance, Lobell et al. (2011) found that each degree-Celsius increment in temperature could reduce maize yields by up to 8% in Africa.

In the midst of climate change impacts on food security, farmers have developed a range of coping strategies to manage climate risks and ensure food production. Such measures according to Makate et al. (2016) include adjusting planting dates, diversifying crops, using drought-tolerant varieties, and integrating agroforestry systems. Others are water conservation practices like mulching, small-scale irrigation, and rainwater harvesting, common in many regions. In Uganda, for example, farmers have adopted intercropping and planting early-maturing crop varieties to deal with shortened rainy seasons (Nabikolo et al., 2012).

Coping effectively with such climate-induced food insecurity requires combined efforts with both institutional and technological interventions. These included improving access to climate information services, agricultural extension, credit, and climate-resilient infrastructure which enormously enhances farmers' capacity to adapt (Kurgat et al., 2020). Moreover, digital tools such as mobile-based weather forecasts and market information systems are helping farmers make informed decisions, thereby improving food availability even in unfavorable seasons. Research shows that combining traditional knowledge with modern technologies yields better resilience outcomes (Thornton et al., 2018). As climate change intensifies, empowering farmers with tools, knowledge, and support systems will be key to ensuring food security for future generations. However, there is limited research conducted to-date in remote areas with alarming food insecurity and rising populations like the Bukedi sub region.

## **2.8 Summary of the research gaps**

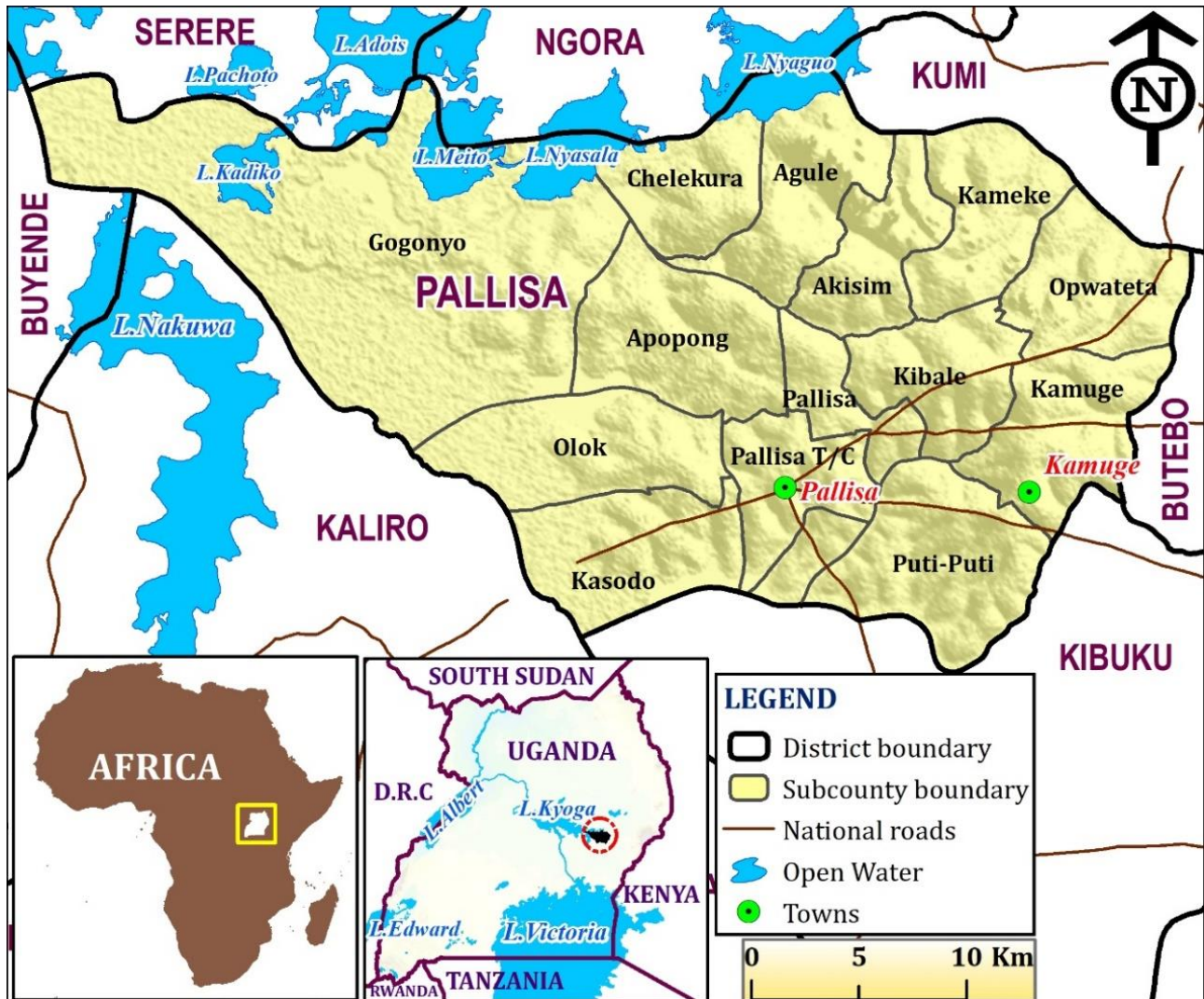
Climate change is already impacting food security through multiple, interacting pathways: reduced crop yields and stability from rising temperatures and changing rainfall patterns, increased frequency of extreme events (droughts, floods) that disrupt production and supply chains (Mirzabaev et al., 2023; Owino et al., 2022). Although climate change is impacting on food security, there has been less research effort on other components of food availability besides production. Besides, less is known about the coping responses employed at the different stages of food availability. There is lack of empirical evidence on which coping responses are reliably employed to ensure food availability at the different levels of the food availability chain. Many studies document what strategies households production strategies on-farm (Gebre et al., 2023; Hadley et al., 2023).

## CHAPTER THREE: STUDY AREA AND METHODS

### 3.1 Study area description

#### 3.1.1 Location

This study was undertaken in Pallisa District, located in Eastern Uganda at 1.1707°N, 33.7099°E. The district is situated within Bukedi sub-region which falls within the “cattle corridor” of Uganda (Figure 2).



**Figure 2:** Location of Pallisa District

### **3.1.2 Climate**

The area is characterized as humid to semi-arid making it susceptible to recurrent climatic hazards such as drought, and floods, alongside significant natural resource degradation (Chombo et al., 2018). These climatic vulnerabilities combined with the high poverty rates prevalent within the region, render Pallisa particularly susceptible to the adverse impacts of climate change (Uganda Bureau of statistics (UBOS), 2024); Pallisa District, 2019).

### **3.1.3 Population**

The demographic profile of Pallisa District further underscored its vulnerability. The district experienced a rapid increment in human population with an average annual growth rate of averagely 4.26%.

The total population of Bukedi sub-region as per the recent national census is approximately 2,376,744 persons, the females making about 1,206,825 whereas the males make approximately 1,169,919 (Uganda Bureau of Statistics, 2024). This implies an average annual growth rate of 2.4 % among the highest growth rates in the country with that of Uganda being about 2.9 % per year (Uganda Bureau of Statistics, 2024). This rapid population growth directly intensified the demand for food resources, which were already climate-vulnerable. The escalating demand placed additional strain on agricultural land and natural resources, thereby exacerbating existing food availability challenges.

### **3.1.4 Economic activities**

Majority of Pallisa's population, specifically derive their livelihood from agriculture with over 89.3% of the total population indulging in agricultural practices as the main household livelihood activity (Uganda Bureau of Statistics, 2014). This overwhelming dependency on agriculture as the primary household livelihood activity rendered the community exceptionally vulnerable to the vagaries of climate change. Consequently, a study contributing to knowledge on climate change, its impacts and coping responses enhances community resilience and adaptation in relation to food security given the district's foundational economic reliance on climate-sensitive agricultural activities.

### 3.2 Study Design

This study employed a cross-sectional survey research design (Cui et al., 2020) where both quantitative and qualitative methods of data collection were used for a comprehensive understanding of the complex interplay between climate change and food availability in Pallisa District. The essence of conducting a cross-sectional survey was because of its ability to provide a reflection of a population or phenomenon at a single point in time (Wang and Cheng, 2020). This design also enables researchers to collect data on variables such as behaviors, attitudes, experiences, or health conditions simultaneously, allowing for the assessment of the prevalence and distribution of specific characteristics within a target group. Finally, because it captures data in the present moment, a cross-sectional survey is particularly useful for identifying relationships or associations between variables without requiring long-term follow-up.

Quantitative data were primarily collected through survey semi-structured questionnaires. These instruments were designed to gather measurable data on observed changes in temperature and rainfall, their perceived impacts on various aspects of food availability, and the adaptation practices adopted by households. This provided a statistical foundation for identifying trends and relationships.

Qualitative data were obtained through Focus Group Discussions (FDGs) and Key Informant Interviews (KII). FDGs facilitated group interactions, allowing participants to build upon each other's ideas and provide enriched information (Krueger & Casey, 2015) about food availability amidst climate change. These discussions specifically targeted different gender groups, including men and women, to ensure representative voices and views from diverse perspectives on climate change impacts and coping responses.

Key Informant interviews were conducted with resourceful persons, specifically the Agricultural officer, Natural resource officer, and Production officer of Pallisa District. The key informants were necessary because they possessed specialized knowledge (Pahwa et al., 2023) and broader institutional perspectives on climate change trends, agricultural practices, and food system dynamics at the district level. Their insights provided a valuable broader-level understanding that complemented the data gathered from households and other middlemen in the FDGs. Furthermore, the KIIs served a vital role in verifying data obtained from the household survey questionnaires,

thereby enhancing the overall validity and credibility of the findings through triangulation of information. This study's scope encompassed understanding how climate change impacts interact with the entire food production and supply chain in Pallisa district.

### **3.3 Sampling Design**

#### **3.3.1 Sample Size Determination**

A reconnaissance survey was initially conducted to identify the sub counties most affected by climate related impacts. These included Kameke, Gogonyo and Opwateta with a combined total of 10,310 households. The number of households in these sub counties are; 2810, 4838 and 2662 respectively (Pallisa District, 2019). To determine the appropriate sample size for the household survey, Krejcie and Morgan sample size determination formula (Krejcie & Morgan, 1970), was applied. Based on this calculation, a total of 375 households were enrolled in this study. The number of households that were selected in Kameke, Gogonyo and Opwateta were 102, 176 and 97 respectively.

Beyond the general farming households, food processors, distributors, and traders (referred to as middlemen) were recognized as distinct segments of the food value chain requiring a targeted sampling strategy. A specialized list frame for these middlemen was created within the randomly selected villages and parishes, with assistance from local council leadership and insights from Key Informant Interviews. From these compiled lists, individuals were selected using simple random sampling. A total sample size of 45 individuals was targeted for interviews across the three sub-counties. This sample comprised 15 individuals from each of the three selected sub-counties, with an equal distribution of five food processors, five food distributors, and five food traders per sub-county.

#### **3.3.2 Sampling**

Multistage stratified sampling was used in this study to generate the required household sample size. A total of three Sub Counties from Pallisa District were selected using purposive sampling which included Kameke, Gogonyo and Opwateta Sub County. This selection was based on anecdotal reports by the Pallisa district local government, which indicated that these specific sub counties were severely affected by flooding, drought, pests and diseases. Additionally, reports

from the Uganda Bureau of Statistics (UBOS) (2017) indicated that over 90% of households within these Sub-Counties relied on small scale farming for livelihood, primarily growing crops like cassava, rice, and maize. Hence any disturbance in the production and distribution of food would greatly damage the livelihoods in the area.

Within each of the selected sub-counties, three parishes were randomly selected. Subsequently from each of these selected parishes three villages were further randomly chosen for the household survey. This systematic process resulted in the random selection of a total of 9 parishes and 27 villages for the study (Appendix 1). Due to the absence of documented household lists within the selected villages, a crucial step involved constructing a comprehensive sampling frame. This was achieved through close collaboration with the respective village council leadership, who assisted in enlisting all households within their jurisdictions. The carefully developed village household lists then served as the primary sampling frame for the household survey from which individual households were enrolled into the study using simple random sampling techniques. Specifically, each household on the compiled list was assigned a unique numerical identifier. A random number generator was then employed to select the required number of households from this numbered list, ensuring that every household had an equal and independent chance of being included in the survey.

The Krejcie and Morgan sample size determination formula (Krejcie & Morgan, 1970) was used to estimate the sample size required in this survey.

To effectively sample the middlemen, processors, distributors, and traders who form the backbone of Pallisa's food system and largely operate outside formal registries a two-step, link-tracing methodology was employed. Initially, frame construction involved mapping during market days with the assistance of local council leaders, supplemented by nominations from Key Informant Interviews (KIIs), to generate a preliminary list of actors within each village. This was followed by a snowball recruitment phase, where each identified actor was asked to name peers in their respective lines of work. This iterative process continued until no new names emerged, indicating saturation of the network. Snowball methods were chosen for their recognized efficacy in accessing hard-to-reach or informal groups where comprehensive lists are unavailable. Once a consolidated sampling frame was established, a simple random sampling technique was applied to

select 15 interviewees per sub-county. These were proportioned equally, comprising five processors, five distributors, and five traders, resulting in a total sample of 45 middlemen.

### **3.4 Data Collection**

#### **3.4.1 Trends in rainfall and temperature**

Previously collected climatic data including minimum and maximum temperature values as well as total rainfall amounts were acquired from the NASA website, an online data repository. This data was downloaded into a spread sheet format, containing daily records for a period of 31 years, specifically from 1990 to 2021, at a resolution of two meters. This comprehensive dataset provided the empirical basis for analyzing long term climate trends in Pallisa district.

#### **3.4.2 Climate change impacts on food availability and household coping responses**

Data on the climate change impacts as well as food availability components including production, processing, distribution and trade were systematically collected using a multi-faceted approach involving both household surveys and interviews with the key market actors.

To conduct the household data collection, a semi-structured questionnaire was utilized. This tool was designed to gather information on the climate change impacts experienced by households, as well as their coping responses to sustain food availability in a changing climate. The questionnaire covered key sections including socio-demographic characteristics of the respondents, climate change impacts experienced by households on various food availability components including; production, processing, distribution and trade and the specific coping responses employed. At food production level, the questionnaire focused on key variables such as yield and quality of crops. For food processing data collection concentrated on the household food processing techniques such as fermentation, sundrying and drying. At the distribution level, information was gathered on food storage technologies and transportation networks. Lastly, market prices, household income and the dynamics of food distribution and access to markets.

The questionnaire was pretested in Opwateta Sub County in Pallisa District to check for reliability and identify any potential errors that were made during automation. Necessary revisions were made but these required changes were made before embarking on the field household survey.

The household structured interviews only targeted households that had lived in Pallisa district for least ten (10) years. Within these households, the family head was targeted for the interviews but in the event that the household head was not available, the next mature individual was interviewed.

The Focus Group Discussions (FGDs) were used to supplement the data from household surveys. The group interactions allowed participants to build on each other's ideas to providing enriched information about food availability amidst climate change.

The FGDs targeted different gender groups including men and women to obtain representative voices and views from the gender perspective about climate change impacting food availability and the coping strategies employed in their areas.

Two Focus Group Discussions were conducted, each comprising of 15 people, with at least 05 females per group held in each sub county using a checklist of questions regarding food availability and climate change. The checklist covered aspects on climate change occurrence, its related impacts and how they influence food availability. The coping responses employed by households to sustain food availability were also discussed during the FGD meetings. The FGDs targeted households involved in food production, processing and trade in Pallisa District.

### **3.5 Data cleaning and processing**

Data processing is a critical step in preparing survey data for analysis to ensure accuracy, consistency, and reliability of the results. In this study, the process involved identifying and correcting errors, such as missing values, duplicate entries, and outliers that would otherwise distort the findings. This step also included checking for inconsistencies in responses, correcting typographical errors, and ensuring that variables are properly coded according to the survey design. The process helps to eliminate noise and enhances the quality of the dataset, making it suitable for meaningful interpretation.

Data processing also involved organizing and transforming the dataset into a structured format that facilitates analysis. This included recoding variables and categorizing responses, and applying statistical techniques to summarize key patterns. Proper data cleaning and processing not only improve the credibility of the survey findings but also provide a strong foundation for subsequent statistical analysis and decision-making.

### **3.6 Data analysis**

#### **3.6.1 Trends of rainfall and temperature from the year 1990 to 2020 within Pallisa District**

To compare the variations in rainfall and temperature, one-way analysis of variance (ANOVA) was conducted in Minitab version 2019, with annual rainfall and temperature being the response variables while the years were predictors. ANOVA was used to compare means among multiple groups to determine if at least one group mean is significantly different from the others. In this case, the annual rainfall and temperature for the different years were compared to determine if they are significantly different. The adoption of ANOVA for this analysis was based on the numerous degrees of freedom arising from many treatments (years), which warranted an advanced test such as analysis of variance (Montgomery, 2020).

The mean monthly rainfall and temperature for the different years were presented as line graphs portraying the trend in climate. The Tukey's post hoc test was conducted whenever the analysis of variance (ANOVA) showed significant differences. All statistical inferences and tests were conducted at a 95% confidence level.

#### **3.6.2 Impacts of climate change on food availability at household level in Pallisa District**

To assess the impacts of climate change on food availability, the study first investigated how the socio-demographic variables influenced the perceptions of climate change impacts. The socio-demographic and climate change impact variables were first presented using descriptive statistics. This was followed by binary logistic regression between each climate change impact as the dependent variable and the socio-demographic characteristics as the independent variables. Logistic regression is a statistical technique that measures the relationship between binary outcomes (in this case, climate change impacts) and predictor variables (socio-demographic variables). It estimates the probability of the binary outcome variable given the values of the predictor variables.

Binary logistic regression was intended to demonstrate the relationship between the different impacts and how they influence food availability components within Pallisa district. The regression was used to investigate the perceived impact of climate (temperature and rainfall) change on food production, processing, distribution and exchanges (Bourguignon et al., 2007).

Farming households face a total of regimes with regime being the reference category (non-responsive). The data from quantitative analysis was presented in form of tables and line graphs.

Qualitative data from the FGDs was analyzed using thematic-content analysis (Williamson et al., 2018). This was done to generate a clear understanding of the impacts of climate change on food availability.

In order to examine the relationship between household socio-demographic characteristics and the likelihood of experiencing particular climate-change-related impacts affecting food availability, a binary logistic regression model was used.

Let

$$Y_i = \begin{cases} 1, & \text{if household } i \text{ experienced a given impact,} \\ 0, & \end{cases}$$

The probability that a household experiences a particular impact,  $P_i = P(Y_i = 1)$ , is modelled as:

$$P_i = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \dots + \beta_k X_{ki})}}$$

where:

- $P_i$  = probability that the  $i^{th}$  household experiences the impact;
- $X_{1i}, X_{2i}, \dots, X_{ki}$  = independent (predictor) variables such as age, gender, education level, household size, income level, and access to extension services;
- $\beta_0$  = constant (intercept);
- $\beta_1, \beta_2, \dots, \beta_k$  = estimated coefficients showing the change in the log odds of  $Y_i = 1$  per unit change in  $X_{ki}$ ;
- $e$  = base of the natural logarithm ( $\approx 2.71828$ ).

The corresponding **logit transformation** expresses the model in linear form as:

$$\ln \left( \frac{P_i}{1 - P_i} \right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki}$$

A positive coefficient ( $\beta_j > 0$ ) implies that as the predictor variable increases, the likelihood of the household experiencing the specified impact or adopting a coping response also increases, and vice versa. The regression was implemented in Minitab 2019, with statistical significance determined at the 95 % confidence level ( $p < 0.05$ )

### 3.6.3 Coping responses to climate change impacts on food availability in Pallisa District

Coping responses utilized by respondents to ensure food availability were analyzed using descriptive statistics of mean and standard deviation. Logistic regression was used to establish the relationship between climate change (temperature and rainfall) and responses by households to ensure food availability. The results were presented in tables while the qualitative data was analyzed using thematic-content analysis (Williamson et al., 2018).

In order to examine the relationship between household socio-demographic characteristics and the likelihood of adopting particular coping responses to climate change related impacts affecting food availability, a binary logistic regression model was used.

Let

$$Y_i = \begin{cases} 1, & \text{if household } i \text{ adopted a coping response,} \\ 0, & \text{otherwise.} \end{cases}$$

The probability that a household adopts a coping response,  $P_i = P(Y_i = 1)$ , is modelled as:

$$P_i = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \dots + \beta_k X_{ki})}}$$

where:

- $P_i$  = probability that the  $i^{th}$  household adopts the coping strategy;
- $X_{1i}, X_{2i}, \dots, X_{ki}$  = independent (predictor) variables such as age, gender, education level, household size, income level, and access to extension services;
- $\beta_0$  = constant (intercept);
- $\beta_1, \beta_2, \dots, \beta_k$  = estimated coefficients showing the change in the log odds of  $Y_i = 1$  per unit change in  $X_{ki}$ ;
- $e$  = base of the natural logarithm ( $\approx 2.71828$ ).

The corresponding logit transformation expresses the model in linear form as:

$$\ln \left( \frac{P_i}{1 - P_i} \right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki}$$

A positive coefficient ( $\beta_j > 0$ ) implies that as the predictor variable increases, the likelihood of the household adopting a coping response also increases, and vice versa. The regression was implemented in Minitab 2019, with statistical significance determined at the 95 % confidence level ( $p < 0.05$ )

### **3.7 Data Quality Control**

To ensure the high quality and integrity of the collected data, several rigorous measures were implemented throughout the research process. The questionnaire was standardized through pre-coding which facilitated consistent data entry and analysis. Prior to the main data collection, a reconnaissance survey was conducted within Pallisa town. The primary purpose of this pretesting phase was to assess the clarity, reliability and validity of the tools in eliciting the desired information. This also helped in identifying any potential challenges that might be encountered during the actual data collection.

Results obtained from the pre-test were subjected to expert judgment, specifically from the academic supervisors, who provided technical guidance for making necessary adjustments to the tools. This iterative process aimed to refine the instruments to ensure they consistently yielded accurate data.

### **3.8 Reliability**

The reliability of the questionnaire, a measure of its internal consistency was assessed using Cronbach's alpha coefficient set at 95% confidence interval (Fischer et al., 2012). The expectation was that the obtained value would be higher than the recommended threshold, indicating strong internal consistency.

### **3.9 Validity**

Validity which refers to the accuracy of the data collection tool in measuring the intended characteristic or attribute was tested using (Bolarinwa, 2015). the Content Validity Index (CVI).

$$CVI = \frac{R}{R + N + IR}$$

Where; R refers to relevant, N for neutral and IR for irrelevant.

Screening and categorizing of the questions in the tool was done with technical guidance from the academic supervisors. The closer the CVI to 1, the more valid is the attribute question (Xi, 2010). Also, during the actual data collection, responses were checked to eliminate any errors or mistakes. After undergoing these entire steps, the data were be assumed to be of good quality and ready for analysis.

### **3.10 Ethical Considerations**

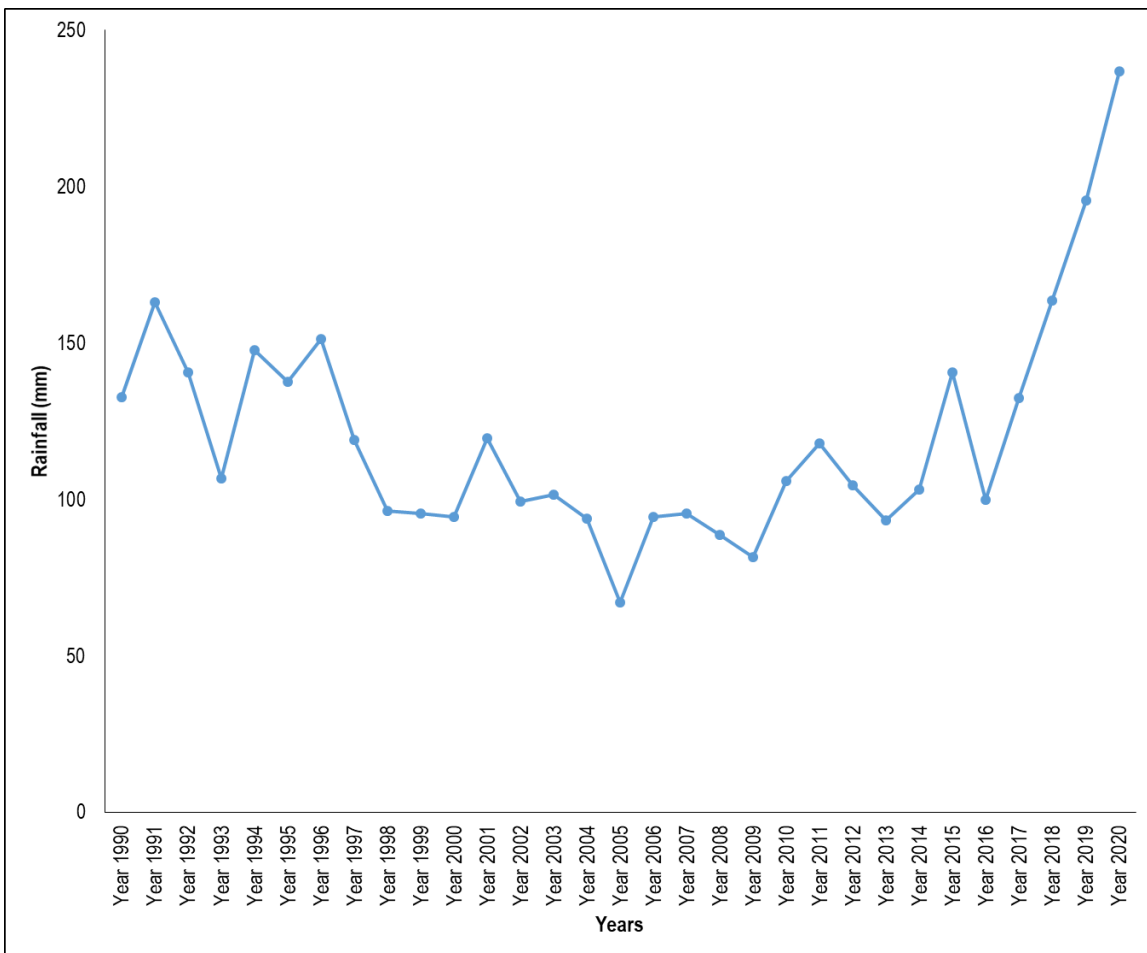
In upholding the highest ethical standards throughout the fieldwork study, several key principles were adhered to. Prior to any data collection, the informed consent of all research participants was diligently sought and obtained. This process involved clearly articulating the objectives of the study to the participants. Transparency was maintained by explaining the potential benefits that might accrue from their involvement such as dissemination of master thesis to the District authorities who could utilize the findings for planning related activities or interventions. Participants were also informed of any potential risks or unpleasant episodes that might occur during meetings, ensuring they made their decisions to participate with a full understanding of the research content.

## CHAPTER FOUR: RESULTS

### 4.1 The trends in climate change (rainfall and temperature) from 1990 to 2021 in Pallisa District

#### 4.1.1 Rainfall Trends

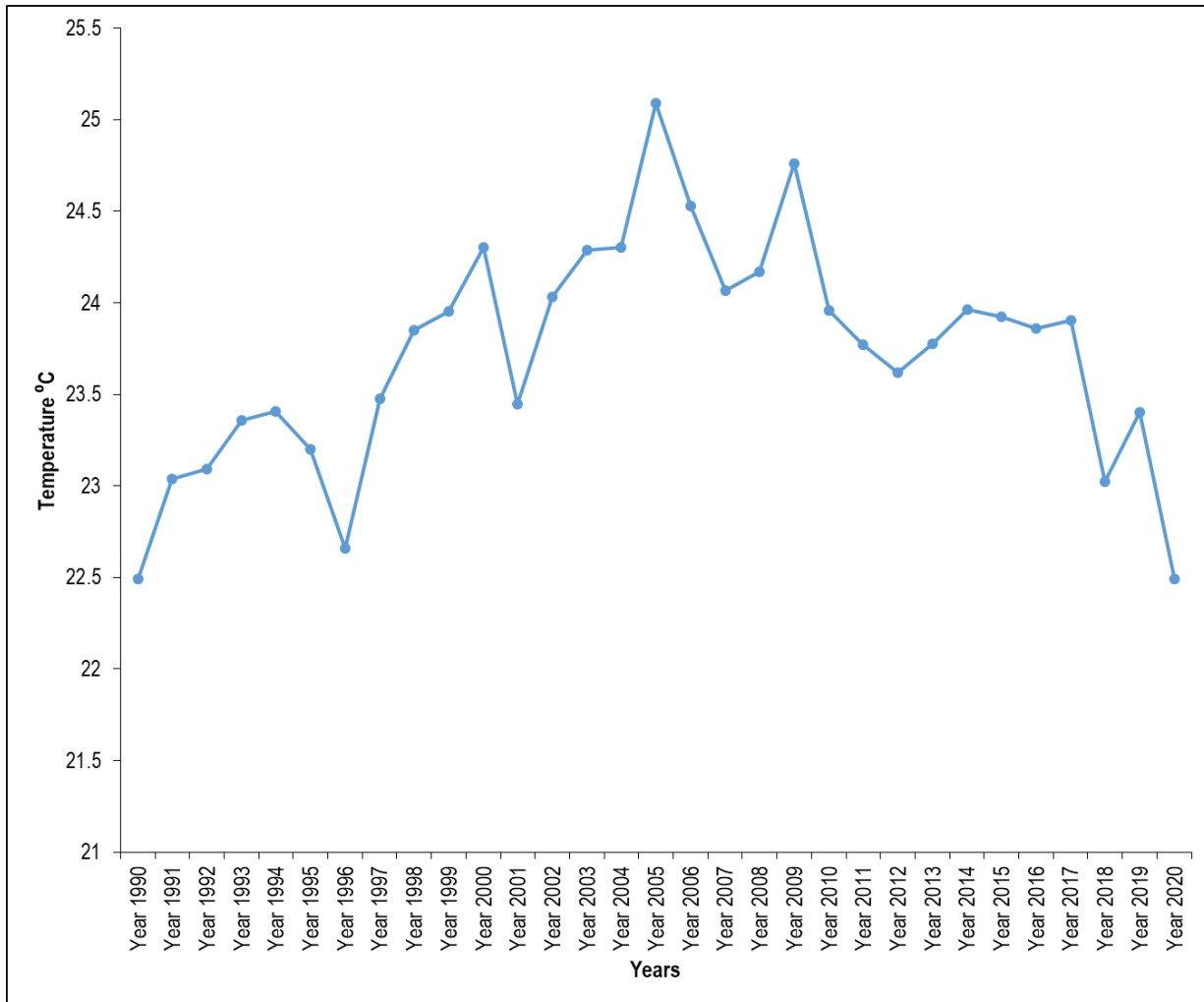
Generally, the mean monthly rainfall varied over the period of thirty-one years from 1990 up to 2020 (Figure 4). There were more rapid oscillations from the year 1990 up to 1996, and 2000 up to 2016. Generally, low rainfall levels were registered in the period between 1997 and 2014 while a sharp increase in the amount of rainfall received was registered in the period between 2016 up to 2020 (Figure 4). Inference assessment using analysis of variance (Table 2) revealed that the mean monthly rainfall for the different years was significantly different ( $DF = 30, 341, F = 2.62, P = 0.000$ ).



**Figure 3:** Variation of rainfall in different years throughout the assessment period, 1990-2020

### 4.1.2 Temperature trends

Generally, the temperatures increased from the year 1990 up to 1994 when they started declining up to 1996 (Figure 5). There was a sharp increase in temperatures from 1996 up to 2000 when temperatures started declining up to 2001. From 2001, temperatures started rising up to the year 2005 where the highest average temperatures were recorded for the entire analysis period of thirty-one years since 1990 up to 2020. There were generally several fluctuations from the year 2012 up to 2020 but generally the temperatures were declining.



**Figure 4:** Variation of temperature in different years throughout the assessment period, 1990-2020  
Analysis of variance (Table 1) revealed that the mean temperatures were significantly different ( $DF = 30, 341, F = 1.85, P = 0.005$ ) for the different years.

**Table 1:** One-way analysis of variance of rainfall and temperature versus years

Parameter	Source	DF	SS	MSS	F-Value	P-Value
Rainfall	Year	30	457085	15236	2.62	0.000
	Error	341	1985131	5821		
	<b>Total</b>	<b>371</b>	<b>2442217</b>			
Temperature	Year	30	138.9	4.629	1.85	0.005
	Error	341	851.8	2.498		
	<b>Total</b>	<b>371</b>	<b>990.7</b>			

*DF =degree of freedom, SS= sums of squares, MSS= mean sums of squares.*

The Tukey's post hoc test method grouped the years into three categories, A, B and C following significant differences in rainfall recorded (Table 2). Years with letter A under grouping were not significantly different and recorded the highest mean monthly rainfall. The year 2020 recorded the highest mean monthly rainfall and was significantly higher than most of the years while 2005 recorded the lowest mean monthly rainfall.

**Table 2:** Mean monthly rainfall grouping information using the Tukey's post hoc method. *Means that do not share a similar letter are significantly different.*

Year	Mean	Grouping		
2020	236.9	A		
2019	195.6	A	B	
2018	163.5	A	B	C
1991	163.0	A	B	C
1996	151.2	A	B	C
1994	147.7	A	B	C
2015	140.6	A	B	C
1992	140.6	A	B	C
1995	137.6	A	B	C
1990	132.7	A	B	C
2017	132.3	A	B	C
2001	119.5		B	C
1997	119.1		B	C
2011	117.8		B	C
1993	106.8		B	C
2010	105.9		B	C
2012	104.6		B	C
2014	103.3		B	C
2003	101.5		B	C
2016	99.8		B	C
2002	99.3		B	C
1998	96.2		B	C
2007	95.4		B	C
1999	95.4		B	C
2000	94.5		B	C
2006	94.5		B	C
2004	94.0		B	C
2013	93.2		B	C
2008	88.8		B	C
2009	81.7		B	C
2005	67.2			C

The Tukey’s post hoc test method grouped the years into two categories, A and B following significant differences in temperatures recorded (Table 3). Years with letter A under grouping were not significantly different and recorded the highest mean monthly temperature. The year 2005 recorded the highest mean monthly temperature while 2020 recorded the lowest mean monthly temperature.

**Table 3:** Temperature grouping information using the Tukey’s post hoc method. *Means that do not share a similar letter are significantly different.*

<b>Year</b>	<b>Temperature (°C)</b>	<b>Grouping</b>	
2005	25.1	A	
2009	24.8	A	B
2006	24.5	A	B
2004	24.3	A	B
2000	24.3	A	B
2003	24.3	A	B
2008	24.2	A	B
2007	24.1	A	B
2002	24.0	A	B
2014	24.0	A	B
2010	24.0	A	B
1999	24.0	A	B
2015	23.9	A	B
2017	23.9	A	B
2016	23.9	A	B
1998	23.8	A	B
2013	23.8	A	B
2011	23.8	A	B
2012	23.6	A	B
1997	23.5	A	B
2001	23.4	A	B
1994	23.4	A	B
2019	23.4	A	B
1993	23.4	A	B
1995	23.2	A	B
1992	23.1	A	B
1991	23.0	A	B
2018	23.0	A	B
1996	22.7		B
1990	22.5		B
2020	22.5		B

### 4.1.3 Socio-demographic characteristics of the study population

The average age of respondents was 42.2 years with most of the respondents being females (Table 4). The majority of the respondents were married followed by those who widowed/ widowers while most of them had only attained primary level of education (Table 4).

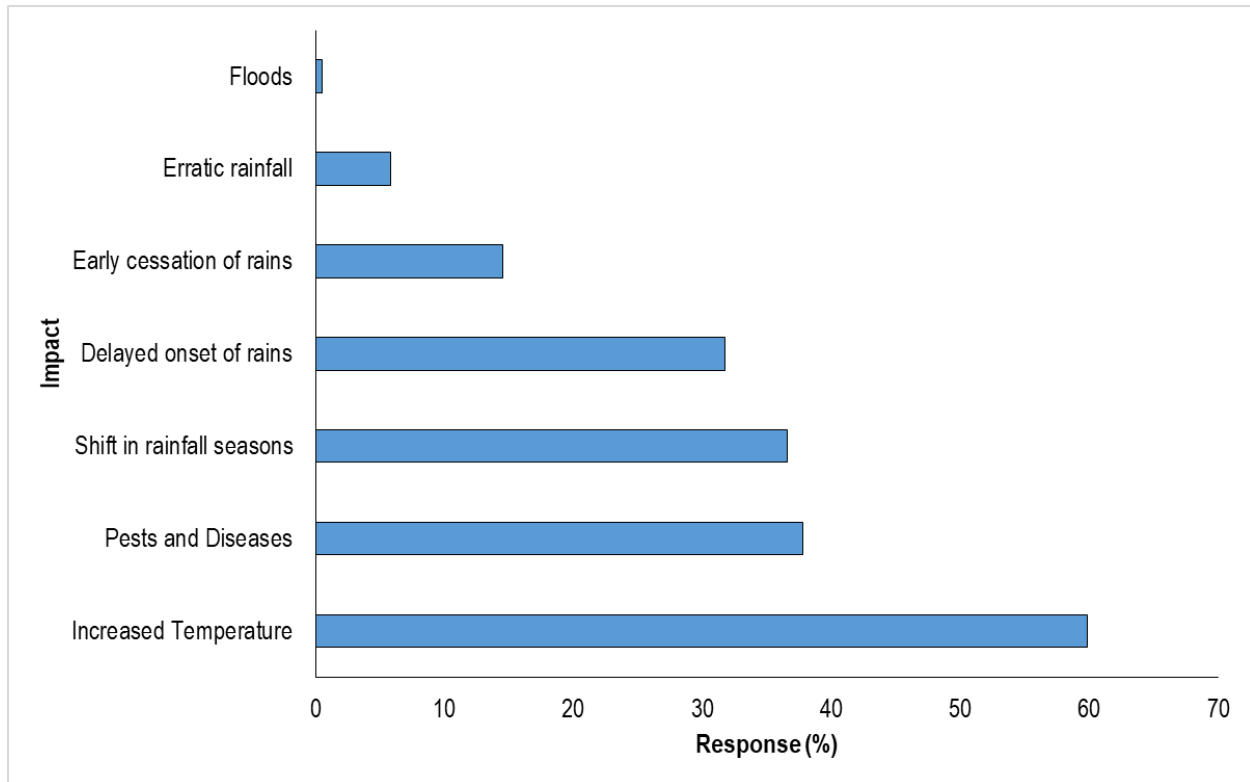
**Table 4:** Socio-demographic characteristics of respondents

Socio-demographic variables		Mean	Std. Error of Mean
Age		42.17	.672
Household Size		8.06	.215
Children		5.42	.184
Adults		2.99	.110
<b>Frequency (n=413)</b>			
Gender	Male		168
	Female		245
Marital status	Married		357
	Single		10
	Cohabiting		1
	Widow/Widower		36
	Divorced		7
	Separated		2
Education levels	No Formal Education		70
	Primary		264
	Secondary		68
	Specialized/ Vocational Training		3
	Graduate (Diploma/ Degree)		7
	Post-Graduate (Masters/ PhD)		1

## 4.2 Perceived impacts of climate change on food availability (Food production, processing, storage, distribution and trade)

### 4.2.1 Impacts of climate change on food production

The most common impacts of changes in climate on food availability were increased temperature (59.8%), followed by pests and diseases (37.8%), shift in rainfall season (36.6%) and delayed onset of rains (31.7%), among other impacts (Figure 6) which results into low crop yields.



**Figure 5:** Reported impacts of climate change on food production at household level

All the climate change impacts with an exception of floods showed a significant positive, correlation indicating that these factors exacerbate challenges in food availability in Pallisa district. For food production, erratic rainfall, shift in rainfall seasons, pests and diseases, and early cessation of rains respectively, revealed the most substantial positive effects, suggesting they are the most detrimental to food production as compared to other factors. Some of the major observed impacts at production stage were; reduction of yield (crop and livestock) as reported by 94% of respondents, delayed onset of rains affected yield for 76.3%, early cessation of rains causes reduced yield and stunted growth for 88.3% of the respondents. From the analysis, floods did not significantly affect food production ( $P > 0.05$ ).

Table 5: Climate change impacts to food production

Model	Food production	
	<i>Coef.</i>	<i>P&gt; z </i>
(Constant)	-1.354	0.000
Increased Temperature	0.268	0.000
Delayed onset of rains	0.7253	0.000
Early cessation of rains	0.755	0.000
Erratic rainfall	0.979	0.000
Drought	0.487	0.000
Floods	-0.205	0.532
Pests and Diseases	0.786	0.000
Shift in rainfall seasons	0.892	0.000

#### 4.2.2 Impacts of climate change on food processing and storage

Regarding food processing and storage, erratic rainfall had the highest coefficient (2.097), followed by delayed onset of rains (0.663) and early cessation of rains (0.566), highlighting the distinct effects of rainfall patterns on food processing and storage. Some of the most reported impacts by the study were; increased spoilage owing to pests and diseases (98%), loss of moisture leading to increased spoilage of harvested crops and processed foods due to increased temperature (81%), reduced water availability for food processing and cleaning (80%) largely caused by early rainfall cessation, and reduced water availability for food processing and cleaning (71%). From the analysis, floods did not significantly affect food processing and storage ( $P > 0.05$ ).

Table 6: Climate change impacts to food processing and storage

Model	Food processing and storage	
	<i>Coef.</i>	<i>P&gt; z </i>
(Constant)	-1.129	0.000
Increased Temperature	0.198	0.000
Delayed onset of rains	0.610	0.000
Erratic rainfall	1.872	0.000
Drought	0.371	0.000
Floods	-0.351	0.288
Pests and Diseases	0.661	0.000
Shift in rainfall seasons	0.132	0.025

#### 4.2.2 Impacts of climate change on food processing

Regarding food processing, erratic rainfall had the highest coefficient (0.982), followed by delayed onset of rains (0.910), highlighting the distinct effects of rainfall patterns on food processing. The most reported impacts by the study were; reduced yields leading to low quantities of food material to process, increased spoilage due to pests and diseases (93%), loss of moisture leading to increased spoilage of processed foods due to increased temperature (88%), reduced water availability for food processing and cleaning (83%) largely caused by reduced water availability for food processing and cleaning (76%).

**Table 7:** Climate change impacts to food processing

Model	Food processing and storage	
	<i>Coef.</i>	<i>P&gt; z </i>
(Constant)	-1.129	0.000
Increased Temperature	0.198	0.000
Delayed onset of rains	0.910	0.000
Erratic rainfall	0.982	0.000
Drought	0.461	0.000
Pests and Diseases	0.543	0.000
Shift in rainfall seasons	0.132	0.025

#### 4.2.3 Impacts of climate change on food distribution

In respect to food distribution, erratic rainfall and early cessation of rains recorded the highest coefficients, indicating that they pose the most significant challenges to food distribution. The common impacts reported as a result of erratic rainfall and early cessation of rains included delays in distribution and supply of food in the area markets, and increase in food prices. From the analysis, floods significantly affect food significance levels, with p-values exceeding the typical threshold of distribution ( $P > 0.05$ ).

**Table 8:** Climate change impacts to food distribution and trade

Model	Food distribution & trade	
	Coef.	$P >  z $
(Constant)	-0.949	0.000
Delayed onset of rains	0.663	0.000
Early cessation of rains	0.566	0.000
Erratic rainfall	2.097	0.000
Drought	0.192	0.000
Floods	-0.067	0.040

*“A 48-year-old trader from Opwateta Oladot cited increased temperatures in their community which reduces rice yields and heavily affects his rice trading business. ....the low yields result into food shortages and scarcity in the area. I am prompted to move longer distances to other areas while sourcing food. This increases transport costs and the food prices on the market”.*

Another 30-year-old man, a trader from Opwateta-Onyamatumga cited shifts in the rainfall seasons which distracts the timing of planting seasons.

*“..... the rainfall comes at unexpected times which delays planting and sometimes causes failures in germination of some seeds. This in turn affects the food yields and the prices on the market. I usually purchase and stock the food in bulk during the times of high yields..... this helps me to have enough supply to meet the local demands even during the times of low yields.”*

#### **4.2.4 Impacts of climate change on food trade**

Regarding food trade, erratic rainfall and early cessation of rains showed the highest effect recording the highest coefficients, implying that they exert the most significant challenges to food trade. Some of the most common impacts reported as a result of erratic rainfall and early cessation of rains were delays in distribution and supply of food into the area markets, and increased prices. From the analysis, floods did not significantly affect food trade ( $P > 0.05$ ) although the relationship was negative (Table 9).

**Table 9:** Climate change impacts to food distribution and trade

Model	Food distribution & trade	
	Coef.	$P> z $
(Constant)	-0.652	0.000
Delayed onset of rains	0.573	0.030
Early cessation of rains	0.602	0.000
Erratic rainfall	0.977	0.003
Drought	0.362	0.001
Floods	-0.046	0.860

### 4.3 The coping responses to climate change impacts on food availability in Pallisa District

#### 4.3.1 Production

The notable responses as summarized in Table 10 included; early planting (80%), crop diversification (60.4%), adoption of early maturing crop varieties (49.1%) and planting resistant crop varieties (38.6%). Other coping responses, including fertilizer inputs to address reduced soil fertility, (Table 10). In response to water scarcity, households engaged in rainwater harvesting (29.4%) and drilling alternative water sources (23.5%). To cope with the disrupted planting and harvesting seasons, the farmers adopted early planting practices (83%), crop diversification, involved using early warning information (66%) and planting early maturing crop varieties among others.

Table 10: Coping responses to climate change impacts on food production in Pallisa district

Coping responses	Count	%
Early planting	88	83
Crop diversification	235	60.4
Adoption of early maturing crop varieties	52	49.1
Planting resistant crop varieties	150	38.6
Use of fertilizers	126	32.4
Increased use of pesticides	115	29.6
Rain water harvesting and storage using water tanks	10	29.4
Move distances to search for water	10	29.4
Construction of alternative water source (drilling wells)	8	23.5
Planting near wetlands/lakes	7	20.6
Diversification of Livestock	26	6.7
Rearing of resistant livestock breeds	12	3.1

Model	Coef.	Std. Err	t	P> t
Coping with reduced yield (crop and livestock)	4.71E-07	1.90E-07	-2.47	0.016
Copying with reduced soil fertility	5.46E-08	2.30E-07	-0.24	0.813
Coping with shortage of water for irrigation & watering animals	1.55E-07	3.32E-07	0.47	0.643
Coping with disruption in the traditional timing of planting and harvesting	-5.88E-08	1.24E-07	-0.48	0.636
Coping with reduced fertility of animals and increased proneness to diseases	3.16E-08	6.20E-07	0.05	0.96
_cons	-0.16528	7.23E-07	-2.3E+05	0.000

### 4.3.2 Processing

Regarding food processing, several coping responses were being undertaken. These included value addition practices like drying, milling or grinding which also enhance shelf life, prompt removal of damaged or infected produce, Access credit and financing options to invest in improved storage facilities, and borrowing money to stock large food quantities among other responses (Table 11).

**Table 11:** Coping responses to climate change impacts on food preprocessing and storage in Pallisa district

Coping responses	Count	%
Value addition practices like drying, milling or grinding which also enhance shelf life	109	80
Prompt removal of damaged or infected produce	9	69
Access credit and financing options to invest in improved storage facilities	3	60
Borrowing money to stock large food quantities	144	54
Adopting water-efficient Food Processing techniques such as drying	33	52
Adopt better storage facilities such as resilient granaries or food stores	67	46
Participating in training and capacity building programs focusing on disaster preparedness	2	40
Utilize emergency food reserves	83	31
Participation in training programs, and workshops to learn about improved post-harvest handling techniques, storage methods, and food processing technologies	66	25
Enhanced post-harvest handling techniques and practices	31	16
Investing in on-farm water storage facilities such as small reservoirs or tanks	8	13
Sought food assistance and support from Local government authorities	13	9.5

Results show that 98.1% of households used electric and diesel-powered mills, 41.4% employed mortars and pestles, and 16.5% utilized grinding stones in food processing. These practices reveal

a diverse range of processing techniques employed by households to ensure food availability and enhance the shelf life (Table 12).

### 4.3.3 Storage

The common storage techniques used in Pallisa district are also presented (Table 12). The study shows that 99% of the respondents store the food in their houses especially the grains in polythene bags, nylon sacs and tarpaulins, while 0.7% use granaries, and 0.2% stored in the garden or on rooftops, and 0.7% utilize a designated food store. Furthermore, 99.8% of the respondents indicated that they first preserve the food through drying, fermentation whereas 0.2% have adopted smoking or salting techniques especially for animal food products like fish (Table 12).

A 60-year-old female trader from Opwateta – Oladot dealing in rice, beans and maize flour cited shifts in rainfall seasons as among the climate change impacts in their area. *“There are shifts in rainfall seasons which affect the drying of harvests/produce leading to unbalanced supply and low prices in excess supply. In most cases delayed harvest prompts sourcing food from further places which increases the transportation costs”*.

**Table 12:** Techniques used to process and store food in Pallisa district

		Frequency	Percent
How food is stored after harvesting or buying	Granaries	3	0.7
	In the house	409	99.0
	In the garden	1	0.2
	On rooftops	1	0.2
	Food store	3	0.7
How households preserve food to make it last longer	Drying	412	99.8
	Fermentation	2	0.5
	Smoking	1	0.2
	Salting	1	0.2
Food processing tools or equipment	Mortars and pestles	171	41.4
	Electric and diesel-powered mills	405	98.1
	Grinding stones	68	16.5

The regression model reveals that coping responses damages of the processing facilities and equipment was significant ( $\beta = 4.22$ ,  $p = 0.000$ ). The increased spoilage, reduced water availability, contamination, and loss of stored food - are not significant predictors of these outcomes ( $p > 0.05$ ).

Most respondents' coping strategies targeted access to credit and financing purposely to invest in improved storage facilities, equipment, and technologies, establishing collaborations and market linkages with local cooperatives, agribusinesses, or food processing companies, improvising tools and equipment using locally available materials, and participating in training and capacity building programs that focus on disaster preparedness and recovery. Other reported coping responses in regards to processing and storage were using improved drying techniques (85.2%) to reduce crop spoilage and value addition practices (79.6%) to cope to loss of stored food. Respondents also borrow money (54.1%) and create emergency food reserves (31.2%) to cope with increased food shortage.

**Table 13:** Relationship between respondents' characteristics and coping abilities to different food challenges

<b>Model</b>	<b>Coef.</b>	<b>Std. Err.</b>	<b>t</b>	<b>P&gt; t </b>
Coping to increased spoilage of harvested crops and processed foods	0.01	0.02	0.6	0.552
Coping to reduced water availability for food processing and cleaning	0.02	0.03	0.64	0.522
Coping to contamination of stored food	-0.01	0.04	-0.23	0.819
Coping to loss of stored food	-0.03	0.02	-1.1	0.273
Coping to damage of storage infrastructure	0.28	0.18	1.53	0.127
Coping to damages of the processing facilities and equipment	4.11	0.07	60.6	0.000
Coping to increase in food shortage	0.02	0.02	0.85	0.396
_cons	-0.12	0.03	-4.6	0.000

#### 4.3.4 Distribution and trade

The main coping practices to high distribution and trade costs reported were buying food directly from farmers, substitution with alternative locally available foods, Utilization of foods with a longer shelf life as compared to perishable foods, and Borrowing money to purchase and stock large quantities of food among others (Table 14).

**Table 14:** Coping responses to climate change impacts on food distribution and trade in Pallisa district

<b>Coping response</b>	<b>Frequency</b>	<b>%</b>
Buying food directly from farmers	189	71.1
Substitution with alternative locally available foods	141	53

Utilization of foods with a longer shelf life as compared to perishable foods	85	48
Borrowing money to purchase and stock large quantities of food	133	44.9
Engaging in bartering to access a variety of food items	112	42.1
Engaging in multiple income generating activities to boost income to purchase food	7	28
Use of local transportation solutions such as animal-drawn carts	3	12
Use of emergency food reserves	10	8.6
Doing preservation and storage practices to extend the shelf life of perishable foods	2	8

Another 30 year old man, a trader from Opwateta-Kanyamatunga cited shifts in the rainfall seasons which distracts the timing of planting seasons. *“..... the rainfall comes at unexpected times which delays planting and sometimes causes failures in germination of some seeds. This in turn affects the food yields and the prices on the market. I usually purchase and stock the food in bulk during the times of high yields..... this helps me to have enough supply to meet the local demands even during the times of low yields.”*

*“A 48-year-old trader from Opwateta Oladot cited increased temperatures in their community which reduces rice yields and heavily affect his rice trading business. ....the low yields result into food shortages and scarcity in the area. I am prompted to move longer distances to other areas while sourcing food. This increases transport costs and the food prices on the market”.*

*“..... sometimes there is too much rainfall which causes spoilage and affects the quality of food which leads to unstable food prices ..... we tend to move to other areas like Soroti and Kumi district to get good quality food” ... says a 48-year-old man, a food distributor from Opwateta - Olwakai dealing in maize, cowpeas and groundnuts.*

Results of the regression of the coping mechanisms employed by different households (X) and the likelihood of experiencing specific impacts on food distribution and trade, Y (Table 15). The study revealed a less likelihood of the people in Pallisa District to cope to delays in food supply, and disruption in the transportation and communication channels ( $p < 0.05$ ).

There was also a low likelihood of coping to increased food prices, increased transportation costs. Conversely, there was a significant likelihood of coping to reduced availability in the markets ( $\beta = 1.05, p = 0.000$ ).

**Table 15:** Coping means to delayed food supplies

<b>Model</b>	<b>Coef.</b>	<b>St. Err</b>	<b>t</b>	<b>P&gt; t </b>
Coping to delays in food supply	-0.10	0.03	-3.53	0.000
Coping to disruption in the transportation and communication channels	-0.21	0.05	-4.13	0.000
Coping to reduced availability of some foods in markets/area	1.05	0.03	34.81	0.000
coping to reduced overall supply of food for distribution	0.05	0.03	1.56	0.120
Coping to increased food prices	-0.09	0.02	-4.88	0.000
Coping to increased transportation costs	-0.03	0.03	-1.05	0.294

## CHAPTER FIVE: DISCUSSION

### 5.1 Trends in rainfall and temperature in Pallisa District from 1990-2020

It was established in this study that there was a statistically significant difference in the minimum temperature in Pallisa throughout the span of 30 years examined, implying that climate change in Pallisa district has been significant. This evidence of climate change as has been reported in the other parts of the world and has been reported and has been reported to affect food security through promoting pests and diseases reducing agricultural production and subsequently food availability to the populations. For example, the rise in temperatures have been reported to cause heat stress in food crops like rice, maize and wheat resulting into a decline in yields. Asseng et al. (2015) for example showed that a unit rise in temperature can decrease global wheat yields by about 6%. Deutsch et al. (2018) also indicated that an increase in temperatures results in expansion of the range and lifecycle of crop pests and diseases, damaging food crops and reducing the availability of food, especially in tropical and subtropical regions.

On the other hand, in Sub-Saharan Africa, erratic rainfall has been linked to poor harvests and food insecurity (IPCC, 2022). Such negative impacts would result into significant disruption of the food availability. In fact, studies like (Wheeler & von Braun, 2013) showed that regions highly dependent on rainfed agriculture e.g., Sub-Saharan Africa, the poor are most vulnerable to these effects. In other instances, such changes in temperatures have been also been cited to result in increased post-harvest losses by accelerating spoilage and making storage harder without refrigeration. Such remote or rural areas like Pallisa are highly likely to experience food spoilage without post-harvest management technologies adopted given the observed trends in their local climate. This has been attributed to pollution and accumulation of greenhouse gasses resulting into significant changes in temperatures and rainfall (Trenberth, 2011).

The geographical variability in altitude, the height above sea level may account for the variability in the minimum temperature (American Meteorological Society, 2021). It has been reported that higher altitudes generally have lower temperatures owing to thinner air than the low altitudes (NASA, 2021) and some parts of Pallisa could be at relatively higher altitudes while other areas are situated at low altitude causing remarkable differences in the minimum temperature.

The changes in climate i.e., rainfall and temperature may also be arising from variable El Niño/La Niña, a phenomena that can influence temperature patterns, potentially leading to significantly cooler periods in certain areas than others (NOAA, 2021). Such changes in the climate of an area impacts the food chain

The differences in the minimum temperatures could also be attributed to climate variability in the area. Studies have revealed that although climate change is habitually associated with global warming, it can also result be due to increased variability and extremes in weather patterns, including periods of unusually low temperatures (IPCC, 2021; NASA, 2021). The Intergovernmental Panel on Climate Change (IPCC, 2021) has also reported that whereas average global temperatures are on a rise, weather variability can lead to colder-than-usual temperatures in the different areas. This is in agreement with several other studies which have already reported evidence of climate change in the eastern region of Uganda although their focus was mainly on the Karamoja sub region (Egeru et al., 2019; Levine et al., 2011).

## **5.2 Effect of climate change impacts on food availability (Food production, processing, storage, distribution and trade**

This study established that climate change affects food availability by increasing pests and diseases, causing erratic rains, shift in rainfall seasons, early cessation of rains causing stunted growth and subsequently resulting into reduced crop and livestock yield. Other impacts included loss of moisture leading to increased spoilage of harvested crops and processed foods as a result of increased temperatures, reduced water availability for food processing and cleaning largely caused by early rainfall cessation. This diversity of climate change impacts may be attributed to the potential variability in the natural environment of the study area triggering immense climate variability and the subsequent related impacts. The diversity of the natural environment causes variabilities in precipitation and temperature patterns leading to unpredictable rainfall, which can cause droughts or floods (Barnett et al., 2005). The droughts can lead to water scarcity, affecting crops' growth, while floods can destroy crops and reduce arable land. The fluctuation in precipitation has also been reported to affect water availability for irrigation, crucial for crop production.

In other instances, the low yields are attributed to fluctuating temperatures as climate change has been indicated to alter temperature patterns which may also results into reduced crop performance. For example, rising temperatures lead to heat stress on crops, reducing yields in several staple crops such as wheat, rice, and maize. For example, Lobell et al. (2011) found out that for every degree Celsius rise, wheat and maize yields could decrease by 6% and 7.4%, respectively. Other studies such as (Peng et al., 2004) have showed that high temperatures during critical growth periods, such as flowering and grain filling, can adversely affect crop development and yield.

The decline in yields and increased spoilage among other impacts is attributed to increased pests and diseases which attack crops and animals on farm and their products in store. It has been well documented that climate change can expand the range and enhance the prevalence of agricultural pests and diseases. For example, warmer temperatures and higher humidity levels may create favorable conditions for pests and pathogens, leading to increased crop damage and reduced yields (Rosenzweig et al., 2001). The findings are in agreement with (Macheka et al., 2022) who also reported that climate change highly impacts food availability and nutrition.

### **5.3 The coping responses to climate change impacts on food availability in Pallisa District**

#### **5.3.1 Production**

Farmers were employing a multiplicity of coping mechanisms to tackle the impacts of climate change in food production including crop diversification and planting resistant crop varieties to enhance crop yield and soil management practices to cope with reduced soil fertility, among others. Soil fertility is widely considered a critical pathway through which climate change influences food availability, particularly in vulnerable regions like sub-Saharan Africa and South Asia. The climate-induced changes such as increased temperatures, altered rainfall patterns, and extreme weather events directly affect soil health by accelerating erosion, reducing organic matter, and disrupting nutrient cycling processes (Lal, 2020). These changes compromise the soil's ability to support crop growth, which in turn threatens food production and security. As soils degrade and fertility declines, agricultural yields fall, undermining the resilience of farming systems and exacerbating food availability risks.

The application of a mix of coping responses is ascribed to the diverse nature of the challenges and lack of a single independent coping response which can solve all the climate related food

impacts. The development and use of agricultural practices and innovations such as climate-resilient crop varieties has been given wide attention and cultivars have been widespread to enhance food production in agricultural communities (International Rice Research Institute, 2019; Mackill & Ismail, 2012). Hence, the adoption of such coping responses in such areas like Pallisa to enhance crop yields as such crops are usually drought-tolerant, flood-resistant, and heat-tolerant (Pimentel, 2009).

Practices like ploughing and mulching reported in Pallisa is perhaps motivated by the wide consensus that these practices enhance soil productivity by maintaining a reliable soil moisture and enhance nutrients availability (FAO, 2013), thus improving yields in food production. The reported coping practices such as climate-resilient crop varieties, improving water management practices, and adopting sustainable agricultural practices are in line with what has been documented by the Food and Agriculture Organisation (FAO, 2016) to enhance resilience to climate change.

### **5.3.2 Processing and storage**

This study established that the respondents employed several coping responses in food processing and storage are employed like access credit and financing to invest in improved storage facilities, establishing collaborations and market linkages with local cooperatives, agribusinesses, food processing companies, and improvising equipment using locally available materials in addition to participating in training and capacity building programs that focus on disaster preparedness and recovery. The use of such multiple coping responses is influenced by their costs, availability and accessibility of the approaches to the farmers. The farmers for example due to the widely distributed small-scale financial service providers like the Saving and Credit Cooperative Organizations (SACCOs) are able to access finances while capacity building trainings and programmes might be regularly provided, easing adoptability by the farmers. Such responses have also been reported in previous studies to enhance coping to climate change challenges. For example, Sarkar et al. (2019) showed that training programs and knowledge transfer initiatives can enhance the technical capabilities of food processors to implement climate-resilient practices such as management of storage pests in food stores. Vermeulen et al. (2012) on the other hand indicated that establishing networks and partnerships among institutions or individuals can facilitate the dissemination of best practices and innovative solutions. While formation of institutions has not

been revealed in this study, it would make a significant influence on the response to climate change impacts among the food processors through knowledge sharing.

Results revealed that in Pallisa farmers have not yet embraced the modern technologies such as development of a cold chain transportation infrastructural system which helps preserve perishable goods foods during transportation and storage, reducing food waste and extending the shelf life of products. This may be attributed to the costs of some technologies which makes them less affordable by relatively poor farmers. The challenges relating to costs have been widely reported to be significant from other studies. For example, Sarkar et al. (2019) and (FAO, 2018) reported high initial investment costs like in implementing advanced refrigeration and energy-efficient technologies which cannot easily be afforded by small and medium-sized enterprises. Several other studies have reported cost related challenges such as the cost of operating the technologies which are high even after installation (Shahbaz et al., 2020) and the cost of raw materials used in processing (Vermeulen et al., 2012) reducing adoptability of the responses.

### **5.3.3 Trade**

This study established that the main coping responses to climate change impacts on food trade were buying food directly from farmers, increased reliance on nearby local markets and direct exchange with neighboring communities through barter trade. The coping responses in food trade are predominantly traditional and rudimentary generated privately from the farmers. The responses are engaged with less intervention from government and Non-Government Organisations which suggests limited influence of formal assistance in the context of food distribution in the area. This may be attributed to lack of clear policies and interventional structure to help in combatting climate related impacts (Vermeulen et al., 2012). Other interventions have equally received less attention in the area, for example the provision of grants, subsidies, and low-interest loans to help businesses invest in climate-resilient technologies and infrastructure from governments and international organizations (Lipper et al., 2014). The study also established that infrastructural development such as roads and food markets are not fully integrated into plans to bolster food trade and accessibility to most populations to lower climate food availability impacts. This is contrary to the global strategic approaches where it is highly tipped to solve climate impacts related to food security (FAO, 2018).

This study about climate change and household food availability generated new knowledge that is critical for understanding, predicting, and addressing the intertwined challenges of environmental change and food security. The study reveals that climate change does not only affect one component of food availability chain (the production component) but rather the whole chain. The study also helps to reveal the causal pathways through which climatic variations such as increased temperature, erratic rainfall, droughts, and floods affect food production and accessibility at the household level. While global studies often focus on agricultural output, localized studies like this one reveal context-specific impacts, including shifts in cropping patterns, soil fertility loss, and post-harvest challenges. This contributes new empirical evidence on how climate-induced environmental stresses translate into household-level food deficits, especially in vulnerable rural and peri-urban settings (Alauddin & Sarker, 2022; Waha et al., 2020).

Studying the intersection of climate change and household food availability also contributes to knowledge on local adaptation and coping responses. It highlights how households modify agricultural practices, diversify livelihoods, adjust diets, or engage in migration to buffer against food shortages. It is envisioned that such studies uncover coping mechanisms and their effectiveness under varying socioeconomic conditions, thereby enriching theoretical and practical understanding of resilience building and adaptive capacity in food systems (Morton, 2020; Niles & Salerno, 2018).

This research provides evidence-based insights for designing targeted interventions that align with the Sustainable Development Goals (SDG 2: Zero Hunger and SDG 13: Climate Action). It contributes to the development of climate-smart food security frameworks that integrate ecological sustainability with social equity and economic feasibility (FAO, 2021a; Smith et al., 2019).

## CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

This study was set out to investigate how climate change impacts food availability in Pallisa District to contribute to household resilience and food security to contribute to achievement of Sustainable Development Goals 2 and 13 on zero hunger and climate action respectively. The focus was on assessing climate change over a period of 31 years from 1990 – 2021, the food supply chain including production, transportation, processing, and trade.

- I. Both temperature and rainfall have greatly changed throughout the period 1990 – 2021 in Pallisa District. Some years experienced sharp declines while others great increments in temperature and rainfall. Interestingly, periods that had sharp increments in temperature also experienced low rainfall amounts.
- II. The delays in in rainfall, rising temperatures, pests and diseases, shift in rainfall seasons, delayed onset of rains and extreme weather events are the most significant impacts to food availability, disrupting food production through crop failures and reduced yields. These climatic shifts are also affecting transport infrastructure, particularly in rural areas, leading to delays and post-harvest losses.
- III. The processing industries are greatly affected by reduced yields due to rainfall changes which lead to low quantities of food material to process and increased spoilage arising from increased pests and diseases.
- IV. Food trade is increasingly volatile due to supply shocks arising from the low production yields triggered by climate-induced scarcity.
- V. These interconnected disruptions highlight the growing vulnerability of food systems in the face of climate change, particularly in low-income communities. If unaddressed, they could worsen food insecurity, increase food prices, and destabilize rural economies. As climate change intensifies, building resilient, adaptive, and equitable food systems will be crucial to sustaining livelihoods and ensuring food security for future generations.

## **6.1 Recommendations**

This study's findings should be interpreted considering several important limitations that also point toward future research priorities. Methodological constraints include potential recall bias in household surveys, sparse meteorological data in rural areas, and challenges in isolating climate impacts from concurrent socioeconomic factors. Future research should employ longitudinal designs with objective food availability measurements (yield records, market data) triangulated with household perceptions, and utilize satellite-based climate monitoring for more precise trend analyses. Scope limitations relate to the single-district focus, which provides contextual depth but limits generalizability across Uganda's diverse agro-ecological zones. Additionally, the temporal design may have missed intra-annual food availability fluctuations critical for understanding acute scarcity episodes during lean periods. Subsequent studies should conduct comparative multi-district analyses, implement continuous monitoring systems to capture seasonal variations, and integrate gender-disaggregated analyses to understand differential vulnerabilities within households particularly given women's central role in household food security management.

### **1. Management recommendations**

On the basis of this research findings, the following management recommendations have made:

#### **For agricultural production**

- i. The government and related activists should continue to promote climate-smart agriculture by encouraging practices such as agroforestry, conservation tillage, and efficient irrigation systems and drought-resistant crops to enhance food availability.
- ii. The government should invest in localized weather forecasting and early warning systems to ensure that farmers get accurate and timely information to make planting and harvesting decisions. This should be accompanied by enhancement of extension services delivery to support farmers with training in adaptive techniques and resilient crop varieties.
- iii. Agricultural research institutions like NARO should continue to promote seed and genetic diversity, encourage the preservation and use of climate-resilient indigenous varieties to buffer against variability.

### **For transport and infrastructure**

- i. Regarding the transport sector, the government of Uganda should invest in resilient transport infrastructure to strengthen rural road networks, bridges, and storage facilities that can withstand extreme weather events.
- ii. The government should also help communities in establishing decentralized food storage systems. These will reduce spoilage and post-harvest losses that arise from climate disruptions during transportation.
- iii. The government should also subsidize green logistics innovations to encourage cold-chain systems powered by renewable energy such as solar-powered storage systems.

### **For food processing**

- i. The government should improve access to affordable technology for smallholder farmers and SMEs that require access to modern food processing equipment.
- ii. The government should also promote diversification in value chains and encourage local food processing to reduce dependence on imports and enhance food security.

### **For trade and market systems**

- i. The government should support climate risk insurance and trade policies that directly or indirectly relate to agriculture and food production. Designing such trade policies will cushion farmers and traders from price volatility that stem from climate extremes.

### **Policy recommendations**

- i. The government should mainstream climate risk in national food security and agricultural policies.
- ii. Together with relevant research institutions, the government should promote research and data collection to guide location-specific adaptation strategies.
- iii. Empower vulnerable groups (e.g., women, youth) with climate-adaptation tools and access to productive resources through legal and policy designs and frameworks.

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## APPENDICES

### Appendix 1: Sampled Sub-counties, Parishes and Villages

Sub county	Parish	Village
Gogonyo	Achango	Morugisa
		Kapara
		Oukoto
	Angodi	Kareu
		Aputon
		Ogisa
	Gogonyo	Obutete
		Kachanga
		Okamo
Kameke	Kameke	Obutete
		Komolo B
		Kameke
	Komolo Manga	Kwapa
		Komolo Manga
		Nyakoi
	Kwarikwar	Ojon
		Otai
		Obilait
Opwateta	Kadesok	Oladot
		Kayepei
		Okutai
	Kapuwai	Aputon
		Abila
		Akipany
	Opwateta	Opwateta
		Okiruket
		Olwakai

## Appendix 2: Impacts of climate change on food production

		Count	Column N %
How increased temperatures affected food (crop and animal) production	Increased pests and diseases	59	23.9
	Withering	95	38.5
	Rapid growth of weeds	27	10.9
	Limited pasture/forage	63	25.5
	Limited water resources	81	32.8
	Reduction in yield	232	93.9
Impact of delayed onset of rains on food (crop and animal) production	Reduced yield (both livestock & crop)	100	76.3
	Delays in planting	96	73.3
	Water stress	39	29.8
	Limited pasture/forage	22	16.8
	Pests and diseases	27	20.6
	Losses and wastage	16	12.2
	Withering	32	24.4
	Rapid growth of weeds	7	5.3
Impact of early cessation of rains to food (crop and animal) production	Reduced yield (both livestock & crop)	53	88.3
	Water stress	22	36.7
	Limited pasture/forage	15	25.0
	Pests and diseases	21	35.0
	Crop losses and wastage	13	21.7
	Reduced soil fertility	28	46.7
	Stunted growth	46	76.7
	Withering	16	26.7
	Rapid growth of weeds	6	10.0
Impact of erratic rains on food production	Reduced yield (both livestock & crop)	18	100.0
	Delays in planting and harvesting	14	77.8
	Water stress	0	0.0
	Limited availability of forage/pastures	4	22.2
	Pests and diseases	8	44.4
	Stunted growth	10	55.6
	Withering	3	16.7
	Rapid growth of weeds	1	5.6
Impacts of drought on food (crop and animal) production	Pasture and water scarcity (for livestock and crop)	169	59.9
	New pests and diseases	96	34.0
	Reduced quality of pastures	119	42.2

	Reduced fertility of animals and increased proneness to diseases	82	29.1
	Emergence of new crop weeds	12	4.3
	Limited flowering of crops due to high temperatures	103	36.5
	Stunted crop growth	255	90.4
Impacts of floods on food (crop and animal) production	Decreased crop yield	2	100.0
	Decreased livestock productivity	0	0.0
	Death of livestock	1	50.0
	Destruction of crop/ farm lands	1	50.0
	Reduced soil fertility	1	50.0
	Reduced water quality	0	0.0
	Disease and pest occurrence	0	0.0
Impacts of pests and diseases on food (crop and animal) production	Increased use of pesticides and acaricides	98	81.0
	Increased occurrence of crop and livestock pests and diseases	38	31.4
Impact of shift in rainfall seasons on food (crop and livestock) production	Disruption in the traditional timing of planting and harvesting	122	80.8
	Longer growing seasons	123	81.5
	Increased vulnerability to pests and diseases	76	50.3
	Water scarcity	105	69.5
	Changes in the availability or activity of pollinators	68	45.0

### Appendix 3: Coping responses to climate change impacts on food production

		Count	Percent
Coping interventions/responses to reduced yield (crop and livestock).	Planting resistant crop varieties	150	38.60
	Crop diversification	235	60.40
	Diversification of Livestock	26	6.70
	Rearing of resistant livestock breeds	12	3.10
	Increased use of pesticides	115	29.60
	Use of fertilizers	126	32.40
Coping interventions/responses to reduced soil fertility	Practicing minimum tillage	6	3.30
	Crop residue retention	24	13.30
	Cover cropping	38	21.00
	Mulching	55	30.40
	Terracing	1	0.60
	Ploughing	61	33.70
	Agroforestry	6	3.30
	Mixed farming practices	100	55.20
	Use of organic fertilizer	35	19.30
Coping interventions/responses to reduced availability of water for irrigation and feeding animals	Construction of alternative water source (drilling wells)	8	23.50
	Rain water harvesting and storage using water tanks	10	29.40
	Buying water from private vendors	0	0.00
	Water harvesting	7	20.60
	Water sharing and borrowing from social networks	1	2.90
	Water treatment to improve the quality	0	0.00
	Only plant when it rains	7	20.58
	Plant near wetlands/lakes	10	29.4
	Move distances to search for water	4	11.76
Coping intervention/ responses to disruption in the traditional timing of planting and harvesting	Use of early warning information	70	66.00
	Early planting	88	83.00
	Adoption of early maturing crop varieties	52	49.10
	Adoption of early maturing crop varieties	7	6.60
	Only plant when it rains	11	10.40
Coping interventions/responses to reduced fertility of animals and increased proneness to diseases	Improved animal husbandry practices such as Proper housing, regular veterinary care, and vaccination programs	55	87.30
	Training sessions on disease prevention and control	7	11.10

#### Appendix 4: Impacts of climate change on food processing and storage

	N	
How climate change impacts affected food processing and storage in households	Increased spoilage of harvested crops and processed foods	189
	Reduced water availability for food processing and cleaning	64
	Disruption in the food processing activities such as washing and cleaning of the produce	7
	Contamination of stored food	13
	Loss of stored food	137
	Damage of storage infrastructure	3
	Damage of the processing facilities and equipment	5
	Increase in food shortage	266
Coping interventions/responses to increased spoilage of harvested crops and processed foods	Improved storage facilities	67
	Utilized improved drying techniques, such as controlled drying or mechanical drying, to reduce moisture content in crops before storage.	161
	Enhanced post-harvest handling techniques and practices	31
Coping interventions/responses to reduced water availability for food processing and cleaning	Invested in on-farm water storage facilities, such as small reservoirs or tanks	8
	Practicing water recycling and reuse.	3
	Community Water Sharing of water resources.	27
	Adoption of water-efficient Food Processing techniques such as drying.	33
	Others	3
Coping interventions/responses to disruption in the food processing activities such as washing and cleaning of the produce	Shifting the food processing activities to when water is most available	3
	Use of alternative food processing techniques that require less water	6
	Ttemporarily storing food until processing activities can be resumed	3
Coping interventions/responses to contamination of stored food	Use of post-harvest pest control practices such as proper cleaning, and fumigation etc	11
	Prompt removal of damaged or infected produce	9
	Adopted better storage facilities such as resilient granaries or food stores	6
	Adopted proper packaging and labelling of food products to ensure hygiene	1
Coping interventions/responses to loss of stored food	Value addition practices such as processing, drying, milling, or grinding to enhance the shelf life and value	109

	Participate in knowledge-sharing platforms, training programs, and workshops to learn about improved post-harvest handling techniques, storage methods, and food processing technologies	43
	Sought food assistance and support from Local government authorities	13
Coping interventions/responses to damage of storage infrastructure	Establishing collaborations and market linkages with local cooperatives, agribusinesses, or food processing companies	0
	Accessing better storage and processing facilities, expanding market opportunities to minimize post-harvest losses	3
	Accessing loans and credit from saving groups and cooperatives	0
Coping interventions/responses to damage of the processing facilities and equipment	Access credit and financing options to invest in improved storage facilities, equipment, and technologies	3
	Establishing collaborations and market linkages with local cooperatives, agribusinesses, or food processing companies	2
	Prioritizing repair and rehabilitation efforts to fix and resume processing activities	1
	Improvising tools and equipment using locally available materials	2
	Participating in training and capacity building programs that focus on disaster preparedness and recovery	2
Coping interventions/responses to increase in food shortage	Depended on government and societal relief	14
	Borrowing money to buy food	144
	Utilized emergency food reserves	83
	Participation in training programs, and workshops to learn about improved post-harvest handling techniques, storage methods, and food processing technologies	66

## Appendix 5: Climate change impacts on food processing and storage

		Count	Column N %
How increased temperatures have affected food (crop and livestock) processing and storage	Loss of moisture leading to increased spoilage of harvested crops and processed foods	200	81.0%
	Susceptibility to bacterial growth, leading to food borne illnesses and reduced food quality	68	27.5%
	Increased insect activity leading to increased infestation	16	6.5%
Impact of delayed onset of rains on food (crop and animal) processing and storage	Reduced water availability for food processing and cleaning	101	77.1%
	Disruption in the food processing activities such as washing and cleaning of the produce	56	42.7%
	Moulding hence food spoilage	20	15.3%
Impact of early cessation of rains to food (crop and animal) processing and storage	Reduced water availability for food processing and cleaning	48	80.0%
	Disruption in the food processing activities such as washing and cleaning of the produce	30	50.0%
	Moulding hence food spoilage	13	21.7%
Impact of erratic rainfall on food (crop and animal) processing and storage	Reduced water availability for food processing and cleaning	10	55.6%
	Disruption in the food processing activities such as washing and cleaning of the produce	13	72.2%
	Moulding hence food spoilage	5	27.8%
	Others	0	0.0%
	q223Others_Specify	0	0.0%

Impacts of drought on food (crop and animal) processing and storage	Reduced water availability for cleaning and processing food	82	29.1%
	Reduced activities to clean and process food effectively due to reduced yield	40	14.2%
	Reduced yield available for processing	180	63.8%
	Increase in food shortage	220	78.0%
Impacts of floods on food (crop and animal) processing and storage	Contamination of stored food	1	50.0%
	Damage of the processing facilities and equipment	0	0.0%
	Damage of storage infrastructure	0	0.0%
	Loss of stored food	1	50.0%
	Others	1	50.0%
Impacts of pests and diseases on food (crop and animal) processing and storage	Increased incidence of fungal diseases	39	25.0%
	Increased spoilage	154	98.7%

## Appendix 6: Climate change impacts on food distribution and trade

		Count	Column N %
How increased temperatures have affected food distribution and trade in the area	Reduced availability of food	214	86.6%
	Increased transportation	25	10.1%
	Increased prices	206	83.4%
Impact of delayed onset of rains on food distribution and trade in your area	Delays in supplying food	80	61.1%
	Reduced availability of food	89	67.9%
	Increased prices	94	71.8%
Impact of early cessation of rains to food distribution and trade in the area	Delays in supplying food	41	68.3%
	Reduced availability of food	44	73.3%
	Increased prices	50	83.3%
Impact of erratic rainfall on food distribution and trade in the area	Reduced availability of food	16	88.9%
	Increased prices	18	100.0%
Impacts of drought on food distribution and trade in the area	Reduced yield due to crop failures leading to the reduced overall supply of food for distribution	228	80.9%
	Increased food prices	256	90.8%
Impacts of floods on food distribution and trade in the area	Delays in supplying food	1	50.0%
	Washing away of roads and bridges	0	0.0%
	Increased transportation costs	0	0.0%
	Reduced availability of food in the area	2	100.0%