NATIONAL DEFENCE UNIVERSITY- KENYA

CLIMATE VARIABILITY AND FOOD SECURITY IN GATUMBA ZONE, BURUNDI

BY

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DECLARATION

This research thesis is my original work and to the best of my knowledge has not been presented for a degree or any other award in any other institution.

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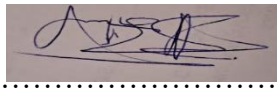
This research thesis has been submitted for examination with our approval as the appointed University Supervisors.



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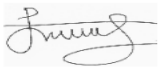

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DEDICATION

This thesis is dedicated to my beloved spouse, Madam Gloriose Ndayisaba, and my dear children, Ntwari Quincy, Kabuhungu Quint Randy, and Dushime Alex Binjamin. They have been my unwavering support system, inspiring me to persevere in pursuit of my dreams.

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LIST OF ABBREVIATIONS

DRC	Democratic Republic of the Congo
FAD	Food Availability Decline
FOA	Food and Agricultural Organization
GDP	Gross Domestic Product
IDMC	Internal Displacement monitoring Center
IFAD	International Fund for Agriculture Development
IPC	Integrated Food Security Phase Classification
NCCRS	National Climate Change Response Strategy
SDGs	Sustainable Development Goals
TOC	Theory of Change
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
USD	United States Dollar
WFP	World Food Program

OPERATIONALIZATION OF TERMS

Agricultural Extension Services: These are the initiatives or programs normally provided through government agencies to offer education, and information to farmers within the rural areas. The aim of the extension services is to educate on best practices.

Climate Variability: Refers to fluctuations in the mean state and other statistical measures of climate across various spatial and temporal scales, extending beyond individual weather.

Crop Diversification: It is the opposite of monoculture when only a single crop is grown. In this study, the concept describes the process of growing different crops together. One of the reasons this happens, is so as to enhance resilience to climate variability and pests, improve soil fertility and health, or to diversify income sources for farmers.

Farm Productivity: It is the output level of agricultural activities, such as crop production or livestock rearing, that can contribute to food security.

Food Insecurity: This refers to a state of inability to access or afford adequate and nutritious food for an active and healthy life.

Food Security: It is the measure of access to sufficient and nutritious food capable of meeting an individual's daily dietary needs.

Risk Perception: Risk perception of an individual is the judgement, attitude or the feelings that they have towards something, in terms of the potential risks that they pose. It is dependent of the personal cultural beliefs, social norms, and experiences.

ABSTRACT

Millions of people across the globe are facing hunger, thus the food security question dominates discussions in global forums today. The growing problem of food insecurity in many nations is attributed to climate variability as the major factor contributing to the declining performance of the agricultural sector in Africa and abroad. Climate variability is observed in the forms of variations in precipitation, temperature, wind patterns and other climate parameters. To establish the link between climate variability and food security, this study undertook to establish the effect of climate variability on food security in Burundi, with a specific focus on Gatumba Zone. The study assessed the effect of droughts on farm productivity in Gatumba Zone, the extent that floods affect agriculture in Gatumba Zone, and lastly, the climate variability coping strategies practiced by farmers to address food security challenges in Gatumba Zone. This study was justified because it can add to the limited research available on the implication of climate variability on food security in Gatumba Zone and to shed light on the challenges of unpredictable climatic conditions on the survival of people. This study was guided by Food Availability Decline theory and the Theory of Change and anchored on case study research design. Both primary and secondary data were utilized in this study. Questionnaires and interviews with key informants were used to collect primary data, while secondary sources included government publications, reports, scholarly articles, newspaper, books, and web links. It was determined that the impact of climate variability on food security is significant. The data collected revealed that farm productivity is affected by droughts. This research found that the drought spells in this region were frequent and had significant effects on farmers' planting decisions, thereby affecting the area's overall farm productivity. It was determined that at the onset of a dry spell, some farmers opt out of planting entirely, while others reduce their planned planting acreage because of the fear of low production. The study established that recurring floods were the major problem in Gatumba Zone as reported by a majority of the respondents. The floods were found to affect the performance of the agriculture sector in this region because they destroyed crops and farms and also occasioned the displacement of farmers, which interrupts their farming activities. It was also determined that farmers in Gatumba Zone undertook diverse strategies to enhance resilience against droughts and floods. Among the strategies were planting of early maturing crops, irrigation, installing a water harvesting system, and mixed crop farming. The study recommends enhanced government investment in dams and water pans to harvest the flood waters which can be used for irrigation during the dry season. The study also recommends increased mobilization of financial resources by the government and other partners to support farmers coping mechanism aimed at addressing climate variability dynamics which affect food security.

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.0 Introduction

This study on the effects of climate variability on Burundi's food security aimed to examine the potential threats that climate variability poses to Burundi's food security, particularly in terms of the role it has played in destabilizing the distribution of food resources and also as a cause for the changing patterns of migration within the country. The effects of climate variability are usually felt disproportionately across the globe. Therefore, a comprehensive approach was deemed essential to provide insight on the effects of climate variability on Burundi food security.

This chapter of the study highlights the statement of the problem that concisely articulates the concern that this research is aiming to address. It elaborates on the importance of exploring the growing threat of climate variability on food security in Burundi. The chapter also presents the objectives that aimed guided the exploration on the relationship between climate variability and Burundi's food security, by assessing the prevalence and impact of climate-related hazards such as droughts and floods, and identifying the current responses to mitigate their impact on food production. The justification of the study revealed why this research is necessary for the policymakers and in academia. The significance of the study informed how this research can influence policy decisions or contribute to the development of effective interventions or practices. Other sub-sections in this chapter included the assumptions, scope and limitations.

1.1 Background

Food security has been a prevalent concern since the turn of the century, driven by alarming statistics on global hunger. United Nations (UN estimated that 800 million people were grappling with hunger in 2021, marking a significant increase of approximately 46 million from the

previous year's figures (FAO, 2022). Projections indicate that these numbers will continue to rise, with Africa bearing the brunt as the most affected region, where around 140 million individuals are facing acute food insecurity, as reported in the Global Report on Food Crises 2022 (World Bank, 2022).

Climate variability has exacerbated food insecurity in numerous countries, contributing to the progressive decline in agricultural production observed over the past five decades in Africa. This term encompasses fluctuations in the earth's climate patterns over short and long timescales, including variations in temperature, wind patterns, and precipitation, among other natural climate parameters. Climate variability accounts for 30% of the change in global agricultural yields, leading households to allocate a larger share of their incomes to staple foods, thereby pushing many into poverty (Verschuur *et al.,* 2021). Insufficient food intake also has adverse effects on the health and wellbeing of individuals.

At the global level, India is one of the countries whose agricultural sector has been greatly affected by climate variability. The food system in this country has been affected by change in the production levels of its agricultural sector (Ajay & Pritee, 2013). The heat waves experienced in this country have negatively affected agriculture and food security. The damage that climate variability causes on crops, especially wheat has affected food supply, which has prompted significant rise in the price of wheat and its products. In a report that was released by the Global Food Policy Report in 2022, it warned that the variability of climate in India is likely to push more Indians towards hunger by 2030 because of the declining production levels.

The variability in temperature and monsoon rainfall in this country affects crop yield. Every 1 °C rise in temperatures reduces wheat production by millions of tonnes. Slight change in both

rainfall and temperature also affects quality of rice, fruits, coffee, tea, vegetables and fruits. Insects and pathogens are also strongly dependent upon temperature and humidity and changes in these parameters affect their population dynamic. The underlying problem is that farmers in this country have also failed to adopt strategies that would reduce the sector's vulnerability to climate variability (Datta *et al.,* 2022). Their adaptability is severely restricted by heavy reliance on natural factor, lack of complementary inputs, and poor institutional support systems.

Regionally, millions of people in Angola do not have access to sufficient food. The drought spells in this country have gotten worse in recent years and have forced about 3.8 million people into food insecurity (UNICEF, 2023). Because of climate variability, the agricultural harvesting seasons record losses of up to 40%, which in turn has affected households' livelihoods and incomes. The low harvests have severely affected access to food especially in rural areas.

According to the International Fund for Agriculture Development (IFAD), majority of Angolans live in rural areas, and largely depend on rainfed agriculture as their source of food and income (IFAD, 2023). Therefore, many households face hunger and poverty because of the erratic rains. Food insecurity in urban areas is also high because they depend on the farm produce supplied by the farmers. So, low production in the rural areas affects the quantity of food supplied in urban areas. Because of the severe drought conditions in Angola, UNICEF has been heavily engaged in the provision of humanitarian assistance to prevent malnutrition among children and save lives of those suffering severe malnourishment.

The impact of climate variability on food security in Kenya is quite noticeable in terms of rainfall irregularity and temperature increase. Climate variations have greatly undermined agricultural production in various agricultural regions in this country. Agriculture is the mainstay

of the Kenyan economy, contributing approximately 25.6% of its Gross Domestic Product (GDP), an indication that it is a major source of food security and income for the rural folk (Ochieng *et al.,* 2016). The dependency on rainfed agriculture has affected both crop and livestock yield. Downing (1992) established that in the semi-arid areas of the country, high temperatures favour production in highland but affects lowland areas negatively. Therefore, agricultural yield declines significantly in the lowlands when the temperature is high and precipitation low.

In response to the challenge of food insecurity posed by climate variability, the Kenyan government has implemented initiatives such as the National Climate Change Response Strategy (NCCRS) to strengthen nation-wide focused actions that can help mitigate the effects of unpredictable climatic conditions on food production (Ochieng *et al.,* 2016). Addressing the threats of climate variability is also a priority in Kenya Vision 2030, a development foot print that is expected to raise the living standards of its people.

Climate variability has had notable effects on Burundi. The weather patterns shift from dry spells, high winds to heavy rains, and these conditions are becoming increasingly extreme and unpredictable. Communities have been destroyed by floods and thousands of people displaced. The consequences of climate shocks on food production in this country are enormous. Majority of the people are subsistence farmers and climate variability is a serious constraint that has affected production. The climate hazards include erratic rainfall, drought, floods and landslides. As a result, domestics demand for food has outpaced demand. Against this background, this research study conducted an in-depth analysis on the effects of climate variability on Burundi food security, with a specific focus on Gatumba zone.

1.2 Statement of the Problem

In Africa, climate extremes, such as droughts, floods, landslides, and windstorms, have become increasingly prevalent. Achieving food security and ending hunger amidst the ongoing impacts of climate variability is a key priority within the Sustainable Development Goals (SDGs). SDG 2 aimed to eradicate world hunger by 2023. However, the 2023 SDG report highlighted that food insecurity remains a pervasive threat to the lives of millions across the globe. The United Nations has established that 9.2 percent of the global population, equivalent to 735 million people, face chronic hunger (United Nations, 2023). It is clear that climate variability has been a key contributor to exacerbating the world's population vulnerability to food insecurity.

According to the United Nations World Food Program (WFP), Africa is greatly affected, and it identified Burundi among the nations facing widespread hunger. At least half of the population is suffering from chronic hunger. Another key indicator is the soaring food prices in Burundi. Thus, food insecurity has led to its classification as one of the "red zone" countries by the WFP. It has also been determined that the total food production in Burundi is capable of covering only 55 days per person per year (WFP, 2021). These repercussions are experienced despite a greater proportion of Burundi's population identifying as farmers.

Different regions face different climatic challenges, and therefore exploring the climate variability effects manifestation in Burundi is key to understanding the reason that the problem of food insecurity persists in this country. Normally, the ripple effects of food shortages can also extend beyond individual households to impact entire communities and the nation's development trajectory. Reduced agricultural productivity not only undermines food availability but also diminishes income opportunities for farmers, perpetuating cycles of poverty and inequality. Furthermore, food insecurity can fuel social unrest and migration, straining the already fragile

systems of governance and exacerbating humanitarian crises. This study therefore comprehensively examined these complex impacts of climate variability on food security in Burundi, and also investigated about the targeted interventions that have been applied to promote resilience, and sustainability, focusing on the Gatumba Zone.

1.3 Objectives of the Study

The objectives of the study were broken down into a general objective that conveys the central idea of this study and specific objectives that provide scope for understanding the nature of the study problem.

1.3.1 General Objective

The general objective of the study was to examine climate variability and food security in Gatumba Zone; Burundi.

1.3.2 Specific Objectives

The specific objectives of this study were as follows:

a. To assess the effects of drought on food security in Gatumba zone.

b. To analyse the extent that floods affect food security in Gatumba zone.

c. To evaluate the coping strategies practiced by farmers to address climate variability in order to enhance food security in Gatumba zone.

1.4 Research Questions

a. How has drought affected food security in Gatumba zone?

b. To what extent do floods affect food security in Gatumba zone?

c. How effective are the coping strategies practiced by farmers to address climate variability in order to enhance food security in Gatumba zone?

1.5 Justification of the Study

Climate variability, characterized by fluctuations in precipitation, temperature, and general weather patterns, poses significant disruptions to agricultural systems. Hence, this study investigating the impact of climate variability on food security in the Gatumba zone was justified. Without it, there would be limited research available regarding the state of food security in the selected study site, attributable to the unfavorable climatic conditions prevalent in this region. Given the vulnerability of the agricultural sector, it was imperative to explore how droughts and floods in the Gatumba zone have impacted agricultural practices and crop harvests. Projections indicate that extreme weather conditions will become more severe in the future, underscoring the necessity to comprehend the impact of these conditions on food systems.

This research aimed to illuminate the danger posed by unpredictable weather conditions on the welfare of the people. Ignoring this area of study would deprive individuals and states of the knowledge required to mitigate the effects of climate variability on food security.

1.6 Significance of the Study

It will contribute to the advancement of scientific knowledge by examining the impact of climate shocks on agricultural production. Furthermore, it deepens understanding of the intricate relationship between climate variability, agricultural systems, and food security, potentially leading to the development of new insights that enhance comprehension of these complex interactions. The data generated by this study can also serve as valuable input for future research endeavors, facilitating more accurate predictions and furthering scientific inquiry.

In terms of practical implications, the research findings offer crucial insights to policymakers, including high-ranking officials in the Ministry of Agriculture and Livestock, regarding the challenges posed by climate variability and its impacts in Burundi. This knowledge can enable policymakers in this sector to develop targeted policies and strategies aimed at addressing these challenges effectively. Given the significant concerns surrounding the sustainability of food systems worldwide, this evidence-based research can provide policymakers with guidance on resource allocation and mitigation strategies that needs implementation. Importantly, this study also offers insight about local vulnerabilities which can help policymakers to design targeted measures that can enhance community resilience to climate-related disruptions in food systems.

This study can also be of benefit to agricultural agencies, disaster management institutions, and other organizations focused on human welfare. The insights gained would be instrumental in the development of support strategies to overcome these challenges, both at the local and at global scale, considering that climate variability affects diverse communities and countries. Moreover, given its direct relevance to human welfare, particularly in terms of access to sufficient food, this study can inform non-state actors such as non-governmental organizations, enabling them to safeguard human health and quality of life. Local farmers in particular can benefit from guidance on suitable climate-resilient agricultural practices to improve harvests, ultimately contributing to food security and livelihood sustainability.

1.7 Assumptions of the Study

This study operated on the premise that climate variability is a persistent phenomenon in Burundi, serving as the foundation for investigating its impact on food security within this nation, with a specific focus on the Gatumba zone. Moreover, it was assumed that the concept of food security encompassed not only food availability but also access and stability, thereby

facilitating a comprehensive analysis of the influence of climate variability on food security. Additionally, the study assumed that a causal relationship exists between climate variability and disruptions in food systems. It suggested that unpredictable climate patterns have the potential to significantly impact agricultural production and the ability of populations to access nutritious food. Further, the study assumed that every household in Burundi had one head.

1.8 Scope and Limitations of the Study

This study was not confined to a specific time frame but rather aimed to encompass both historical and current trends of climate variability and food security in the Gatumba Zone, Burundi. The study utilized the case study method, facilitating an in-depth investigation of climate change variability and its implications for food security. This method was particularly effective when seeking to gain a deep understanding of a complex issue. Given the study's focus on the Gatumba Zone in Burundi, a significant portion of primary data was collected from this specific location. The selection of this location was influenced by its relevance to the study subject, ensuring the findings are contextually grounded and applicable.

Time was a limiting factor in this study because a lot of time was needed for translating the participant responses from French to English before the data analysis could be done. Majority of the responses received from participants was in French, and even the interviews were conducted in this language. Therefore, the researcher was forced to move with speed during the data collection process to ensure enough time is allocated to the processes of translating and analysing the data.

1.9 Chapter Summary

The chapter provides a comprehensive introduction on the study subject on the effects of climate variability on food security in Burundi, with specific attention to Gatumba Zone. The chapter

was the foundation on which the research was based. It first provided an introduction to the aspects of climate variability and food security, recognizing the disproportionate impact of climate variability on vulnerable populations in different countries across the world. It then presented the study's problem statement to show that climate variability in Gatumba Zone as an issue of concern and that its impact on food security needs comprehensive investigation. The objectives of the study were also introduced followed by the research questions. This chapter also presented the justification of the study and the significance of this investigation. It was proven, that the insights produced through this research can be useful to policymakers, academicians, farmers and several other stakeholders. The scope and limitations of this research study were also included in the chapter.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section of the study presented both the empirical literature review, theoretical and conceptual framework. It also identified the gap in the literature. Climate anomalies are growing more common across the globe and their impact on food security is pronounced, which necessitates deeper investigation on the issue.

2.1 Empirical Literature Review

The empirical literature review contextualized the concepts of climate variability and food security, and reviewed literature on the effects of drought on farm productivity, impact of floods on agriculture, and the coping strategies practiced by farmers to address climate variability challenges.

2.1.1 Contextualization of Climate Variability

Climate variability refers to fluctuations in the mean state and other statistical measures of climate across various spatial and temporal scales, extending beyond individual weather events (Neufeldt *et al.,* 2013). Such variability may stem from natural processes within the climate system or external anthropogenic factors. Researchers worldwide have been investigating the detrimental impacts of global warming and their interconnectedness with various events. Global warming is characterized by an increase in the average temperature of the earth, can trigger significant ecological changes (Dubey *et al.,* 2012). Elevated temperatures may lead to alterations in sea levels and modifications in the quantity and distribution patterns of rainfall.

These changes have the potential to intensify the frequency and severity of extreme weather events, including floods, droughts, heatwaves, tornadoes, and hurricanes.

Neufeldt *et al.,* (2013) express that while future climate variability may resemble current patterns, it could also undergo significant changes. Thus, even in scenarios projecting hotter and wetter climates, periods of cooler and drier weather may still occur, and shifts in rainfall patterns might lead to longer dry spells or altered spatial distributions of precipitation. Climate is often defined as the long-term pattern of weather conditions in a specific location, encompassing factors like temperature, precipitation, wind, and other relevant parameters, typically observed over a span of 30 years.

Human activities, particularly greenhouse gas emissions, are progressively altering the climate. However, in the short term, fluctuations in climate largely outweigh the effects of climate change. These fluctuations encompass a wide spectrum, including extreme conditions like intense heatwaves or severe droughts. Individual weather events, including extremes, are likely to also be influenced by future climate changes, potentially becoming more frequent and intense. Present weather extremes offer glimpses into potential future scenarios; what seems unusually hot today may become the new normal in the future, with subsequent extremes being even more intense.

Climate variability is a global issue. Australia experiences a highly variable climate characterized by cycles of drought followed by heavy rainfall, leading to widespread flooding (King *et al.,* 2020). This pattern has been consistent throughout Australia's long-term climate history and is frequently observed in instrumental records spanning the past century. Droughts, varying in duration from short-term to over a decade, such as the Millennium Drought (1997–2009), often end with extensive heavy rainfall events, as seen during the period of 2010–2012 when

Queensland was devastated by floods. The economic repercussions of droughts extend to fluctuations in food and cotton prices and have cascading effects on both regional and national economies. Furthermore, dry conditions increase the likelihood and intensity of bushfires, making them more challenging to manage. The extensive and intense bushfires experienced in eastern Australia during the spring of 2019, continuing into the summer, can be attributed to the dryness of the fuel load exacerbated by persistent drought conditions.

In Latin America, Brazil is among the countries greatly affected by climate variability. Extreme weather events have grown more common in this country, such as extended droughts, especially in the semi-arid areas of this country, and intense rains throughout the country (Mesquita *et al.*, 2016). The authors further explains that although drought would be considered a cyclic environmental condition, but there are periods where this country has experienced severe lack of precipitation for long periods of time, such as was observed in 2010 and 2013.

The extreme weather events, such as droughts, floods, and heatwaves, impact agricultural production and food security in the country. Droughts, in particular, had severe consequences on crop yields, water availability, and pastureland, leading to food shortages, livestock losses, and economic hardships in rural areas (Fonseca *et al.*, 2016). Additionally, changing rainfall patterns affects the distribution of crops like soybeans and maize, which are the key components of Brazil's agricultural economy, further exacerbating food insecurity and poverty, particularly among smallholder farmers and indigenous communities (Macedo *et al.*, 2019).

In India, susceptibility to climate variability is evident, with diverse climatic zones experiencing a range of extreme weather events, including heatwaves, floods, and droughts. These climate-induced shocks have significant implications for agricultural productivity and food security in the country. Droughts, in particular, pose severe challenges for rainfed agriculture, leading to

crop failures, water scarcity, and food shortages, especially in the rural areas (Nagendra *et al.*, 2018). Additionally, changing rainfall patterns and rising temperatures affects the yields of key crops like rice, wheat, and pulses, further exacerbating food insecurity and malnutrition among vulnerable populations (Gupta *et al*., 2019).

Bangladesh is also considered one of the most climate-vulnerable countries in the world, facing recurrent cyclones, floods, and salinity intrusion, which threatened agricultural production and food security. Floods, in particular, have devastating effects on farmland, destroying crops, livestock, and infrastructure, and displacing millions of people each year (Dasgupta *et al*., 2014). Moreover, sea-level rise and increased salinity intrusion exacerbate soil degradation and water scarcity, further compromising agricultural resilience and food availability (Rahman *et al*., 2018). These climate-induced challenges posed significant risks to food security and livelihoods, particularly among smallholder farmers and marginalized communities.

Across African, climate variability manifests through unpredictable changes in temperature and precipitation patterns. It has been reported in various countries like Nigeria, Ethiopia and Kenya. In Nigeria, just as it is observed in India and Brazil. Climate variability manifests through extreme weather events, including floods, heatwaves, and prolonged dry spells, which threaten agricultural productivity and food availability. Floods, in particular, have devastating effects on farmland, destroying crops, displacing communities, and disrupting food supply chains (Olayide *et al*., 2017). Moreover, rising temperatures and changing rainfall patterns affect staple crops like maize and rice, leading to reduced yields and increased food insecurity, particularly among rural populations (Olanrewaju *et al*., 2019). Ethiopia has also been among the highly vulnerable countries in the region to climate variability, with recurrent droughts and erratic rainfall patterns posing significant challenges to agricultural production and food security (Tirado *et al.*, 2010).

When droughts occur, they have led to crop failures, livestock losses, and water scarcity in many parts of the country, exacerbating food shortages and malnutrition (Deressa *et al*., 2008). Vulnerable populations, such as smallholder farmers and pastoralists are disproportionately affected by these climate-induced shocks, further deepening poverty and food insecurity (Devereux, 2007). Kenya has also faced a myriad of climate-related challenges, including erratic rainfall patterns, rising temperatures, and prolonged droughts, which impact agricultural productivity and food security. Droughts, in particular, have severe consequences for pastoral communities, leading to livestock losses, crop failures, and food shortages (Nyangito *et al*., 2018). Additionally, changing climatic conditions affects water availability, soil fertility, and pest dynamics, further undermining agricultural resilience and exacerbating food insecurity, particularly in arid and semi-arid regions (Funk *et al*., 2015).

2.1.2 Contextualization of Food Security

The term food security at its earliest usage referred to global, regional, national food supply and also shortfall in food supply compared to the demand (Shetty, 2015). It was later decided that adequacy of food at the global, regional and national levels was not sufficient, and it would be more relevant to look at it from community, house hold and individual levels. Today, according to the World Bank, the term food security is defined according to the World Food Summit of 1996 as a situation whereby, "…all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Bank, 2023). The term has therefore broadened beyond food supply to include four other main dimensions of food access, availability, utilization, and stability.

This dimension of food availability relates to food supply or availability of food in sufficient quantities (World Bank, 2023 & FAO, 2008). This is highly dependent on what is supplied through domestic production, available stock levels, and net trade. Food availability at the domestic level relates to physical food presence from own production or market. Food access dimension refers to capacity of individuals to access adequate resources for acquiring food. This dimension recognizes that adequate food supply at international or national level does not guarantee food security at household level. This concern is what drives governments to greater policy focus on markets, prices, incomes and expenditures (World Bank, 2023).

Food utilization concerns the body making good use of nutrients in the food. Sufficient nutrients intake by a household is determined by aspects such as household distribution of food, food preparation, feeding practices, and diversity of the diet. Food Stability relates to sustainability in the supply and access to adequate and quality food. World Bank (2023) explains that even if food intake of an individual is adequate today, they are still considered food insecure if consumption is not sustained. Such a person is at risk nutritional status deterioration.

Tacoli *et al.,* (2013) express that food security is achieved out of efficient food systems. The authors also go ahead to express that the spike in the food prices that occurred between 2007 and 2008 is the main reason that food security emerged as a global policy agenda. In the years that followed, there has been continued and growing interest in food systems, which has seen countries focus on developing policies to address food production. Its close connection to poverty is also another reason for the increased scrutiny of this subject globally. Cross-country analyses show that ability of agriculture to reduce poverty is 2-4 times greater than what other sectors can achieve (Shetty, 2015).

The state of global food security shows that regions such as Asia and Africa are experiencing food insecurity (Peng & Berry, 2019). Africa however, surpasses Asian as the most food insecure region in the world because of declining production. The global state of food security is linked to climate variability. Belloumi (2014) adds that unfavourable climatic conditions damage resource base on which agriculture depends, thereby affecting crop production. Climate variability is observed through unpredictable wealth conditions, which creates disruptions and unpredictability in food production. Under such circumstances, yield is greatly affected, which in turn affects consumption.

2.1.3 Link Between Climate Variability and Food Security

Galwab (2013) explains that changes in the patterns of the climate influences the stability in the supply of food within a county. Agriculture, fisheries, and forestry constitute the primary sources of food for human consumption and are profoundly impacted by climate variability. Shifts in climate patterns have led to reduced food production, increased food prices, loss of farm income, land degradation, and compromised food safety due to water pollution. The European heatwave of 2003, as noted by Wheeler *et al*., (2000), resulted in significant crop yield reductions, with Italy experiencing a 35% loss in maize production and a 25% reduction in fruit yields, while France lost 30% of its forage. The intensification and frequency of storms have disrupted hydrological cycles and precipitation patterns, negatively affecting agro-systems and long-term food productivity globally.

Climate change has also degraded natural resources, particularly water, essential for livelihoods, leading to competition and conflicts over scarce resources, such as water, pasture, and land, notably in Africa. Prolonged drought and deforestation, highlighted by Mugwika (2017), lead to

vegetation loss, affecting livestock and fuelwood availability, with significant impacts observed in Kenya and Somalia, where droughts disproportionately affect pastoralists' livestock. The current state of food insecurity is expected to grow worse as FAO anticipates a drastic decline in crop productivity, with Sub-Saharan Africa facing the most severe impacts due to limited adaptation strategies (Mugwika, 2017). Climate variability affects food accessibility by increasing food prices, reducing income, and undermining the ability to afford daily meals, potentially leading to malnutrition and health implications.

Food utilization is also an aspect of food security, and climate change is also closely associated with the spread of vector-borne diseases and new pests that can affect food production and utilization. As highlighted by Howden (2000), the diseases also pose threats to food production and human health. Sociocultural patterns of food production and consumption may shift in response to changing climates, with farmers advised to cultivate drought-resistant crops, altering consumption habits accordingly. In essence, climate variability profoundly affects food systems, livelihoods, and human well-being, necessitating adaptive strategies at individual, community, and global levels.

Climate variability will impact individuals' ability to safely utilize food by altering conditions for food safety and shifting disease pressures from vectors, water, and food-borne pathogens (Schmidhuber & Tubiello, 2017). Diseases, including vector-borne illnesses like malaria, are expected to either spread in response to climate change. A primary concern regarding climate variability and food security is the potential initiation of a detrimental cycle where infectious diseases exacerbate or cause hunger, rendering affected populations more vulnerable to further infection. This scenario can lead to a significant decrease in labor productivity, heightened poverty levels, and even increased mortality rates. All aspects of extreme climatic conditions,

whether drought, increased temperatures, or heavy rainfall, exert pressure on disease dynamics, with mounting evidence indicating their influence on food safety and overall food security.

2.1.4 Effect of Drought on Food Security

According to the UN report, *Drought in Numbers 2022*, droughts cause the largest number of climate-related deaths in developing countries (UN, 2022). Other economic losses as a result of drought have also increased multifold over the last decades. Its effect on farm productivity is significant. Across the globe, the devastating effects of droughts are felt in various countries. Ray *et al.,* (2018) explains that drought causes water deficit which affects plants growth negatively and the end result is reduced crop yield. They describe Texas as a country that has shown great vulnerability to droughts, which is further compounded by the rapidly growing population.

The frequency and magnitude of droughts in Texas keep changing, and its impact on cropping systems and crop production is significant. The extremely high temperature where there is a drought spells, affect the yield of major crops in Texas including soybean, wheat, sorghum, cotton and corn. Ray *et al.,* (2018) express that the water needs of various crops differ. For instance, corn requires more water than sorghum and cotton. Since major drought reduces the soil moisture, the crop yield ends up reducing. Although planting drought-tolerant crops is recommended, Zipper *et al*., (2016) explains that the variability of drought affects the farmer`s ability to plan adequately to mitigate the potential adverse impact it has on agriculture. Ray *et al.,* (2018) conducted a study to evaluate drought impact on corn, sorghum, cotton and wheat in Texas from 2008-2016. It was established that when the drought periods increased, the yield from the farms would reduce.

The impact of climate variability on the food systems in the US Caribbean is also significant. The devastating effects of droughts on farm productivity are observed in Puerto Rico and U.S Virgin Islands (Holupchinski, 2017). Crop losses attributed to drought spells that occurred between 2014-2016 is in millions of dollars. During the 2014 drought, the most affected group was coffee farmers. In 2015, drought adversely impacted plantains, fodder, and grass, with the total losses for the year amounting to about USD$ 14 million (Holupchinski, 2017). When the staple crops are affected, food availability in the households becomes a challenge. Even if food is imported to supplement low local supply, often, such foods may contain preservatives or may be of lower quality, which affects human health. The author goes ahead to say that it is not only long-term droughts that affects productivity in the US Caribbean, but the effects of short-term droughts are equally detrimental to farm productivity, especially when it occurs during key crop development stages such as planting or flowering. It ends up stunting the crops growth resulting in low quantity and quality of produce.

Summer *et al.,* (2023) took on a different perspective from Ray *et al.,* (2018) and Holupchinski (2017) in determining how droughts affect farm productivity. They focused their study on how farmers' decisions are affected by drought and how it affects the quantity of the harvest. He established that when drought occurs during the pre-planting season, farmers tend to decrease the acres they had planned to plant. Booth *et al.,* (2020) agree that pre-planting conditions form the farmers' risk perceptions and expectations. When drought begins during the pre-planting season and the farmers expect it to get more severe, they end up reducing the number of acres they were planning to plant, especially in the drought-sensitive and less productive lands. This kind of selective planning ends up affecting yield.

Mali, a country in West Africa, has also been grappling with the effects of droughts on farm productivity. This is a country characterized by climate variability and therefore highly vulnerable to extreme climatic conditions. According to the World Bank, Mali experiences recurrent droughts that have altered the composition and characteristics of its vegetation (World Bank, 2023). It experiences crop losses of up to USD$9.5 million annually because of droughts. The growing number of droughts in this country vary in the degree of severity.

As a nation heavily dependent of agriculture as the major source of food and livelihood, droughts present a major threat to the food security in Mali and Malian farmers are finding it increasingly difficult to meet the food demand in the country. The situation is further exacerbated by the fact that arable lands in this country are limited and there is also poor diversification of crops (Montaud, 2019). The major cash crops include rice and cotton, while subsistence crop production has concentrated on sorghum, rice, millet and maize. Farmers in this sector have been producing low yields, which has contributed greatly to the widespread poverty in this region. Caritas (2022) explains that because of low yields as a result of recurrent droughts, about 4.8 million of the population in Mali is food insecure.

In East Africa, several countries are prone to climate variability, especially droughts. In recent years, this region has experienced increasing trend of extreme temperatures. According to Gebrechorkos (2020), this explains why it is among the most food insecure regions around the globe, Drought is a major challenge because majority of the people are farmers. Ahmed *et al.,* (2023) study focused on Somalia as one of the countries in this region that has endured progression in dry seasons since 2000, sometimes extending even up to a period of three years.

During such periods, crop yields, which are highly dependent on precipitation, are unfavourably affected, and the effect is observed in the form of diminished harvest yield. The author further mentions that declining farm yields in Somalia is a cause of food deficiency, declining incomes, rural-urban migration. The further expressed that agriculture is key to the economy not only because it assures it of food security, but because it interacts with other industries. Also, a nation with a steady agricultural sector tends to be viewed as a socially and politically stable country.

Drought however is a persistent problem in Somalia that has caused major reduction in agricultural production. In their study, Ahmed *et al*., (2023) tried to identify the relationship between drought and farming, and they established that when drought increases, farming reduces. When there are fewer people willing to farm, the overall farm productivity reduces. Rowhani *et al.,* (2011) carried out a study to determine how extreme temperatures affect maize, rice and sorghum yields. After the analysis of the data, they found out that when temperature increases by 21°C, production of maize decreases by 5.2%, rice by 6% and sorghum by 5.3%.

Nshuti (2018) also carried out a study to establish the impact of drought on agricultural development in Burundi, Kenya, Rwanda, and Uganda. In this study, the researcher hypothesized that extreme temperatures affect maize production. The results of this study showed that increase in temperature from 1991-2015 affected the quantity of maize produced. These results show that in Burundi and other East African countries, droughts result in declining maize yield.

2.1.5 Effect of Floods on Food Security

Large and catastrophic floods have been observed in diverse areas in recent years (Haraldsen, 2023). It is claimed that these catastrophic events have grown more common now than it was observed previously. Haraldsen explains that plains are important agricultural areas with high

productivity, but their vulnerability to floods is significant. Large floods cause severe damage on agricultural land through direct damage on crops, sedimentation and erosion. Floods wash away a significant amount of topsoil of agricultural lands, which is a loss for agricultural productivity. Generally, the topsoil has high levels of nutrients and organic matter. This reduces the yield in such lands, especially in the short-term.

In his study, Haraldsen (2023) explored flood damage on agricultural land by analyzing the impact of the catastrophic floods that happened in Norway in 1995, which flooded about 14,000 hectares of agricultural land. The damage occurred on these lands either through erosion or sedimentation such that about 1000 hectares could not be used for agriculture any longer until restoration measures were applied. His study found out that crops such as potatoes had almost total failure after logging even in cases where it only lasted for 1-2 days. Delayed growth was another consequence of floods on crops such as hay and grass for silage. As for cereals, the floods caused significant yield loss regardless of the period they were waterlogged. In this study, it was established that different plants have different tolerance levels for floods, which also reflects in the quantity of yield.

Wang *et al.*, (2022) concurs with Haraldsen that flooding and the waterlogging that follows are agricultural disasters that cause remarkable damage on crop production. Wang *et al.*, considers the rushing effect of water as one of the elements that destroys the crops. They also express that the submergence of crops creates abiotic stress on the crops, including oxygen depletion, reduced light availability, and alteration of the chemical characteristics of the soil. A combination of these effects reduces crop stand, growth, and yield substantially. According to Wang *et al.*, (2022), excess rainfall events have grown more common today because of climate change, and reduction in crop yields owing to the floods has been substantial. This has in turn affected grain

supply, thereby creating food insecurity. The authors express that China's agricultural sector suffers greatly the ravages of extreme floods events. The Yangtze River, which is the longest river in this country, is known for frequent floods after heavy downpour.

Wang *et al.,* (2022), the severe flooding affects agriculture along the Yangtze River Basin. The high frequency and long duration of flood disaster combined with water logging are huge challenges to agriculture in Yangtze River Basin. They are responsible for up to 40% yield reduction in this area. As one of the most agricultural areas in the world, which accounts for 28.6% of the total grain production in China and 24.5% of the total crop-harvesting area in China, the effect of flood on crop yield in this area are felt throughout China's food system. Further, the researchers developed a risk evaluation framework that investigated the most important predictor of crop damage during floods in Yangtze River Basin and they established this to be the flood duration. Ochieng *et al.,* (2017) study also found that there is a strong positive correlation between floods and economic damage in terms of crop losses. Therefore, when the duration of flood increases, the more destruction it causes on the agricultural.

Floods also affect agriculture because they prompt farmers to abandon farming and seek jobs in other sectors. The severe damage on agricultural infrastructure can demotivate farmers to continue with the practice, which ends up affecting food security within a country. Flood-induced displacement also affects the agricultural sector. Kakinuma *et al.,* (2020) explains that, floods cause population displacement as people are forced to change their residences permanently or temporarily. In 2018, the Internal Displacement Monitoring Center (IDMC) reported that at least 16.1 million people were displaced because of weather-related events and 5.4 million of them were as a result of floods (Kakinuma *et al.,* 2020). The statistics showed that African countries were the most affected. In 2022, Nigeria was facing the worst floods in a

decade causing the displacement of over 1.3 million people (UNHCR, 2022). Nigeria has a huge agricultural sector that employs about 36% of this country's total labour force, and so when farmers are displaced, they cannot continue with the practice. This creates negative effects on the supply of food in the country. Burundi is also highly vulnerable to flood, and so the effect of floods on agriculture in this zone was a subject of interest in this study.

2.1.6 Coping Strategies Practiced by Farmers to Counter Climate Variability and Enhance Food Security

The adaptive capacity of a country to climate-related hazards has significant impact on food security. Looking at the trend of droughts and floods around the world, these events are only going to get more extreme in the future. This means that they will put mounting strain on agriculture and food security. Therefore, countries require solutions to enhance resilience of their agricultural sector. These include real adaptations or changes in decision-making environment, where the focus is to reduce the effects or improve resilience to extreme climatic conditions, such as droughts and floods.

In Australia, farmers are well experienced in the management of climate variability and extreme weather conditions (Vogel, 2022). They add that farmers in this country modify their farm management practices in order to reduce risks that extreme climatic conditions such as droughts pose on their farming activities. Some of the strategies that they employ include adjusting planting and harvest dates accordingly, modifying irrigation equipment to more efficient systems and applying minimum tillage technique to reduce soil erosion. Farmers also adapt by diversifying through mixed crops farming (Vogel, 2022). Farmers in this country also make good use of agricultural outlook and forecasting information provided by agricultural consultancies

and state departments. This information includes commodity price and weather forecasts. Government support has also been very helpful to the farmers in Australia in helping them adapt to climate variability. The Australian government supports research and innovation to enhance the agricultural sector preparedness against droughts, floods and other extremes.

Hussain *et al.,* (2020) express that farmers in developing countries are highly vulnerable to weather shocks, such as droughts and floods. According to the authors, farmers in such countries face diverse constraints in coping with extreme climatic weather conditions. To ascertain this, they carried out a study in a rural area in Pakistan to determine the factors that hinder farmers from adopting the appropriate coping strategies. Pakistan is prone to extreme events that pose serious threat to this country's agricultural economy and food security. When floods and droughts occur, they ruin crops, which then results in food prices hikes. According to the authors, they established that weather variability in Pakistan puts the farmers at risk because of their dependency on agricultural sector for sustenance.

The study found that in case of floods or droughts, majority of the farmers did not use any coping strategy. A few of them however, used a variety of coping strategies, such as selling their agricultural land, livestock, agricultural machinery or migrating temporarily. Those who sold their resources, did so to support their livelihood since earnings from farming activities were disrupted by weather shocks. Other coping strategies used by a small number of farmers included growing crops that require less water, growing low-input-low-income crops so as to lower the amount investment risked in case of flood, and intercropping. Those who did not adopt any coping strategy explained their reasons as lack of financial means and lack of information.

Kogo *et al.,* (2020) also explored the climate variability in Kenya and coping strategies adopted by farmers. They established that agriculture is a key pillar of this country's economy. The sector's contribution to this country's GDP is approximately 26%. Just like in many other countries, Kenya's agricultural sector is vulnerable to weather shocks which have affected the yield of crops such as wheat, rice, maize and groundnuts, and this has affected food security. Kogo *et al.,* (2020) established that some of the farm-level adaptation strategies used by few Kenyan farmers include mixed cropping, planting of early maturing crops, soils conservation methods such as mulching, terracing and conservation tillage practices, on-farm rainwater harvesting. The researchers established that the choice of coping strategies was dependent on availability of resources and access to agricultural extension services. However, there is limited access to agricultural extension services in this country, which is necessary to drive successful uptake of feasible adaptation strategies to enhance agricultural production (Kogo *et al.*, 2020).

2.2 Theoretical Framework

Two theories were used to guide this study. Food Availability Decline (FAD) theory and Theory of Change (ToC) were selected because of their ability to complement each other in this study concerning climate variability and food security.

2.2.1 Food Availability Decline (FAD) Theory

The FAD approach is credited to the scholarly works of the economist, Amartya Sen (Bowbrick, 2022). One of the core assumptions of this theory is that a sudden reduction of food supply causes famines. It describes that the major causes of this decline are wars, epidemics and natural disasters, such as floods, drought, and pest infestation to mention a few. The FAD approach explains further that, due to the constraints on food availability caused by climatic hazards, the

prices of food commodities rise, posing challenges for vulnerable households in meeting their basic needs (Atubiga and Donkor (2022). This is an approach that underscores that natural phenomena like floods and dry spells have the potential to reduce food production, which is a critical factor leading to food insecurity (Milà-Villarroel *et al.,* 2016). Additionally, it also recognizes that a combination of factors, including deforestation, overgrazing, environmental degradation, and decreased rainfall in arid regions such as Africa, could contribute to a decline in food production. It is a relevant theory in this study because it predicts what the first two objectives of this research seek to establish. The first objective is concerned with the effects of drought on farm productivity and the second is concerned with floods effect on agriculture. As earlier explained, FAD theory emphasizes that droughts and floods can cause a decline in production, which means that farm productivity is affected and the agricultural activities are also hampered.

2.2.2 Theory of Change

Theory of Change (ToC) complements the FAD theory. ToC was proposed by Campbell *et al.,* (2018) in response to the current crisis of food insecurity, especially in the sub-Saharan Africa, which is attributed to adverse weather conditions. In their paper, Campbell at al posed the question; What will it take to increase agricultural productivity…, enhance food security, get rural communities out of poverty, build resilience to climate change, and other stresses…, improve diet and health outcomes" (Campbell *et al.,* 2018)? They resolved that these challenges call for effective actions to transform food systems. To this end, they proposed the theory of change which envisages transformative actions such as digital agriculture, climate-informed advisories and early warning, climate-resilient and low-emission practices and technologies, capacity, and enabling policy and institutions and other elements.

This theory validates the third objective of this research, which sought to investigate the coping strategies applied by farmers to address climate variability challenges. ToC prioritizes empowerment of farmers and institutions to bring the much-needed change in agriculture and food systems (Dinesh *et al*., 2021). ToC therefore is relevant to this study because it proposes various actions that can help overcome the challenges presented by climate variability in the agricultural sector, which has affected food security in diverse countries. As a novel approach, ToC proposes actions that can catalyze transformation of food systems thereby making countries food secure.

2.3 Conceptual Framework

A conceptual framework is the diagrammatic presentation of variables, showing the relationship between the independent variable and dependent variables. The relationship between the independent variables and dependent variable was presented schematically in the conceptual framework in Figure 1.1.

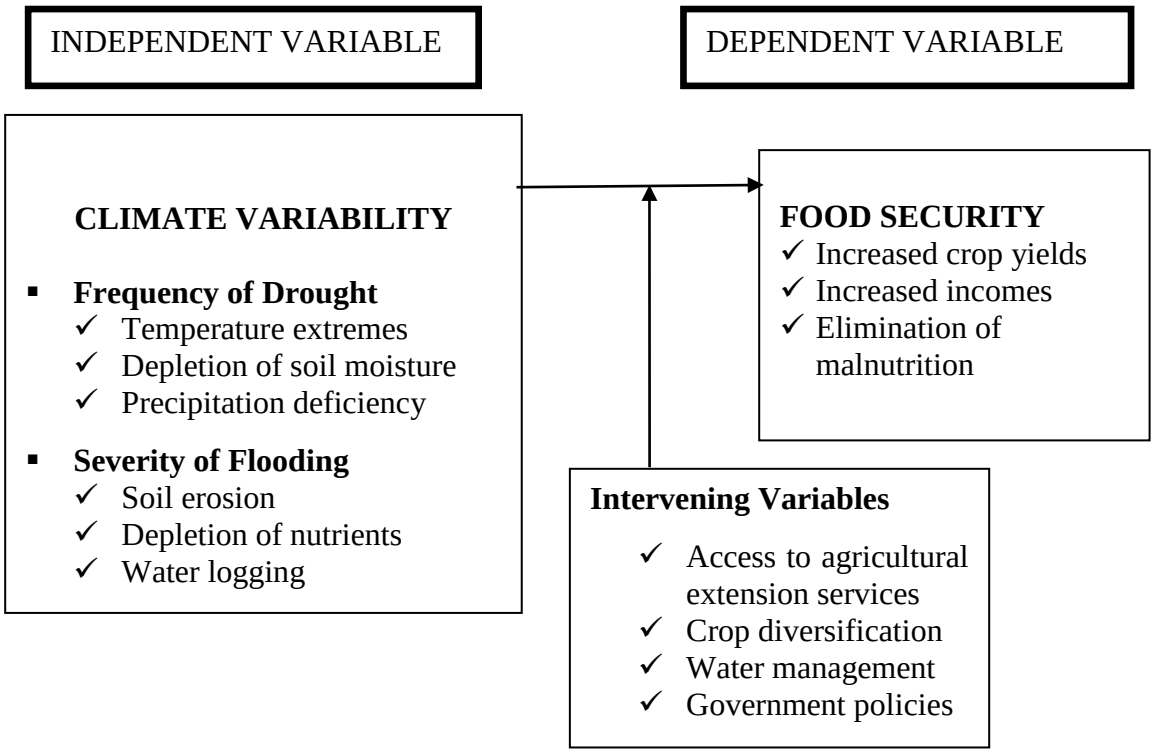

Figure1.1: Conceptual Framework of the Effects of Climate Variability on Burundi Food Security.
Source: Researcher, 2024

Figure 1.1 illustrated the relationship between the study's independent variable, climate variability, and the dependent variable, food security. Within the realm of climate variability, the sub-variables examined were drought and flooding. On the other hand, food security was assessed through indicators such as food availability, access, utilization, and stability. This diagram provided a visual representation of how changes in climate variability may impact different dimensions of food security.

2.4 Research Gap

Several studies have highlighted the dire state of food insecurity in developing countries, particularly in Africa, where highly variable weather conditions exacerbate the situation. The

increasing frequency of droughts and floods has significantly hampered agricultural productivity, leading to limitations in the availability, accessibility, and stability of food. This research aimed to address several gaps identified in the existing literature. Firstly, there was limited investigation into the impact of climate variability in Burundi, and so, this study represents a novel focus of inquiry within the Gatumba zone. Furthermore, it was crucial to identify the specific crops most affected by climate variability and to compare the effectiveness of different resilience strategies employed by farmers against droughts and floods in this region, along with their resultant impact.

2.5 Chapter Summary

The concept of climate variability was explained as fluctuations in climatic conditions that extend beyond the normal weather events usually recorded in a particular region. It is observed to manifest through extreme events like droughts, floods, heatwaves, hurricanes, tornadoes and cyclones. Various researchers have linked these abnormal weather conditions to global warming, as the factor that has been triggering significant ecological changes. The reviewed works also project that in the future, countries are likely to experience wetter and hotter climates. The review also showed that food security is a concept that has been widely discussed and it`s definition has broadened to include not only food supply, but also encompasses access to food, availability, utilization and stability. From this empirical review, it was also determined that droughts affect crop yield because the extreme temperatures reduce the soil moisture and also adversely affects farmers' planting decisions. It was determined that floods affect agriculture because of the significant damage caused on farmland and planted crops. Coping strategies help famers to mitigate these effects. The study adopted the FAD and ToC theories. The former

explained that events such as floods and droughts affect food security, while the latter supported the transformative actions against adverse weather conditions to improve productivity.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter covers the methodology that the researcher applied in executing the research on the effect of climate variability on food security. Research methodology spells out the various methodological processes that the study followed in finding answers to the research question, which in this study was the nexus between climate variability and food security in the republic of Burundi. Therefore, it served as the systematic plan that was utilized to answer the research questions outlined in the first chapter of this study. All the aspects of the research methodology that were applied in this study were discussed hereunder, and they included: the research design, study area, targeted population, sample size and sampling methods, data collection and analysis procedure, validity and reliability, and ethical considerations.

3.1 Research Design

As outlined by Kothari (2012), the research design served as the framework within which this study was conducted. A well-designed research plan enhanced the reliability of collected data while minimizing potential biases. To this end, this study primarily adopted a case study research design. This approach facilitated comprehensive and nuanced investigations into this complex real-world phenomenon of climate variability (Crowe, 2011). Widely recognized across various disciplines, the case study design proves particularly valuable when seeking an in-depth understanding of real-life events, phenomena, or issues. Therefore, in the context of this study, the case study design elucidated the impact of climate variability on food security within the Gatumba zone.

3.2 Study Area

This study was conducted in Gatumba zone, Burundi. Burundi is a landlocked country located in East Africa. It is bordered by Rwanda to the north, Tanzania to the east and south, the Democratic Republic of the Congo (DRC) and Lake Tanganyika to the west. Burundi is a relatively small country in the African continent, known for its hilly terrain and beautiful landscape. Its capital city is Bujumbura. Gatumba zone is situated in the peri-urban area of the city of Bujumbura. It is bordered by Lake Tanganyika to the south, the rural commune of Gihanga to the north, Bujumbura to the south east, and the DRC to the west. The main economic activities of the households in this Gatumba Zone are agriculture, pastoralism, and fishing. The zone has been experiencing various weather dynamics such as flash floods and prolonged periods of droughts which have undermined the food security situation in the country. Gatumba zone has also been a major source of food for the population in Burundi. It is largely because of the climatic changes that this study sought to establish how they were affecting food security in Gatumba zone.

3.3 Target Population

The target population encompasses the specific group or demographic under scrutiny in a research endeavor (Kothari, 2012). In this context, the target population refers to the focus of investigation from which the researcher sought to draw generalizable conclusions regarding the effects of climate variability on food security. Therefore, the targeted population comprised of the heads of households in Gatumba Zone, community leaders in Gatumba Zone, along with government officials working in the Ministry of Environment, Agriculture, and Livestock in the Republic of Burundi. The total target population for the study was 3365, based on data obtained from the bureau for statistics in the country (BCR).

3.4 Sampling Procedure

The sampling procedure outlines the methodology employed by the researcher to identify a subset of the population from which data was derived, effectively representing the targeted population. For the heads of households participating in the study, a simple random sampling technique was employed. Through this method, each head of household within Gatumba zone was afforded an equal opportunity for inclusion. The same approach was applied in identifying the community leaders who participated in this study. Simple random sampling is an unbiased approach for a study that aims to capture the general perspectives and experiences of respondents.

In contrast, for respondents affiliated with the Ministry of Environment, Agriculture, and Livestock in Burundi, a purposive sampling strategy was utilized. This deliberate selection process involved identifying individuals possessing the requisite expertise to contribute meaningfully to the study's objectives. Specifically, individuals knowledgeable about climate variability and its impact on food security within Gatumba zone were targeted for inclusion. The utilization of purposive sampling was instrumental in ensuring that respondents possessed the necessary insights and understanding to provide valuable contributions to the research. By leveraging this targeted approach, the study sought to enhance the depth and relevance of the data collected, thereby enriching the overall analysis and findings.

3.5 Sample Size

The sample size was calculated using Taro Yamane's (1967) formula. The mathematical representation of this method is as follows:

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

N signifies the populations getting studied. The total population for this study is 3365 as illustrated by Table 3.1

e is the margin of error. This study used a margin of error of 0.1.

$n= 3365/ (1+3365(0.1)^2)$

$n= 3365/ (1+3365(0.01)$

$n=3365/ (1+33.65)$

$n=3365/34.65$

$n=97$

Table 3. 1: Target Population and Sample Population

	Target Population (N)	**Sample population (e)**
Households in Gatumba Zone	3210	75
Community Chiefs	55	12
Representatives Ministry of Environment, Agriculture and Livestock	100	10
Total	**3365**	**97**

3.6 Instruments and tools

In this study, semi-structured questionnaires comprising both open-ended and closed-ended questions were employed. These questions were designed to elicit specific, high-quality

responses. Another tool for collecting data that the researcher used was interview guide. It included a list of questions to guide the researcher when collecting data from the key informants. Lastly, books, scholarly journals, reports, reputable websites were used in data collection.

3.7 Validity and Reliability

To ensure the validity of the questionnaire, it was first presented to the research supervisor, who checked whether the questions effectively captured the topic being investigated. The supervisor, being an expert in the field with a clear understanding of the research topic, was best suited to conduct this evaluation. The second step involved conducting a pilot test on the intended population. These two methods were helpful in improving the content of the questionnaires. Reliability, which is the extent to which the questionnaire yields consistent results even after repeated trials, was also assessed through the test-retest method. This was carried out on approximately 10% of the study sample to help eliminate biased, ambiguous, and repetitive questions.

3.8 Data Collection

Data refers to facts presented to the researcher from the environment or phenomenon under study (Creswell, 2014). This research study relied on both primary and secondary data. Primary data is usually sought for its proximity to the truth and its control over error. Such data is appropriate in capturing the relevant experiences and attitudes as presented primarily by the population. Primary data was therefore collected using the questionnaires and key informant interviews. The questionnaires were administered on the households' heads and the representatives from Burundi's Ministry of Environment, Agriculture and Livestock Development. The semi-structured questionnaire, consisted of both open ended and closed ended questions which were

designed to elicit quality responses from the participants. The researcher also developed a key informant guide for the purposes of collecting data from community leaders in Gatumba Zone. Key informant interviews were organized with the community leaders because they are key stakeholders in Gatumba Zone and knowledgeable on matters of climate variability in the region. The researcher notified the leaders ahead of time so that they could prepare for the interviews. Secondary data was also equally vital in this study. Only secondary data from credible sources were used in this study. This data was derived from government publications, reports, scholarly articles, books, and web links.

3.9 Data Processing and Analysis

Data analysis is a process of systematically applying statistical or logical techniques to describe, illustrate, or evaluate the collected data. Data collected from the field was filtered, sorted and cleaned in line with research objectives. The data was then coded before being input into the statistical package for social science (SPSS) software Version 27. Quantitative data was analyzed using descriptive statistics. It involved calculation of percentages, and frequencies. Thematic analysis entailed the creation of themes related to the study variables. This was performed on the qualitative data provided from interviews and the open-ended questions in the questionnaire. The results were presented using tables, graphs and in prose.

3.10 Ethical Considerations

In adhering to the ethical issues, the researcher safeguarded against doing anything that would harm the participants in the study. The researcher sought permission from the participants to have them participate in the study. It was the responsibility of the researcher to interpret the data and present evidence; therefore, informed consent allowed the respondents to choose to

participate or not. Therefore, the researcher ensured that participants were informed, to the extent possible, about the nature of the study. Confidentiality and anonymity were achieved by not asking participants to write their names on the questionnaires.

3.11 Chapter Summary

This chapter provided a comprehensive overview of the research methodology employed to investigate the impact of climate variability on food security in the Gatumba zone of Burundi. It detailed various aspects of the research design, including the adoption of a case study approach to facilitate an in-depth exploration of the research topic. The study area, Gatumba zone, was described, providing context for the research's geographic focus. Additionally, the target population, comprising households in Gatumba zone, Community leaders of Gatumba Zone and representatives from the Ministry of Environment, Agriculture, and Livestock in Burundi, was identified, laying the foundation for data collection. The chapter elucidated the sample design and sampling procedure, which involved a systematic approach for households and purposive sampling for ministry representatives. Instruments and tools utilized for data collection, including interview guide and semi-structured questionnaires, were discussed, along with measures to ensure validity and reliability. Data collection methods encompassed both primary and secondary sources, with emphasis on ethical considerations to safeguard participants' rights and privacy. Finally, data processing and analysis procedures were outlined, encompassing quantitative and qualitative techniques to derive meaningful insights from the collected data.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS OF FINDINGS

4.0 Introduction

This is the chapter that presents the analysis of the data collected, the results and discussion of the findings. The information contained in this chapter is based on the data collected through questionnaire, interviews with the key informants, and it is augmented by information from diverse secondary sources. The study was conducted in view of determining the effect of climate variability on Burundi food security with a specific focus on Gatumba. First, the researcher presents the information of the study participants and then presents the analysis according to the study objectives.

4.1 Analysis of Respondents

Below is an analysis of the study participants: Response rate, gender, age, marital status, education, and occupation.

4.1.1 Response Rate

The table below presents information on the number of respondents who participated in this study.

Table 4.1: Response Rate

	Frequency
Farming households	62
Community Chiefs	4
Representatives Ministry of Environment, Agriculture and Livestock	6
Total	**72**

Source: Field Data, 2024

Table 4.1 shows that a total of 72 respondents participated in this study. The study's sample size was 97 respondents; thus, this was 74% representation. A 74% response rate was satisfactory and gives credence to the study to provide accurate and credible information about climate variability and food security in Gatumba Zone.

4.1.2 Gender

Gender representation of the respondents was as illustrated in Figure 4.1 below.

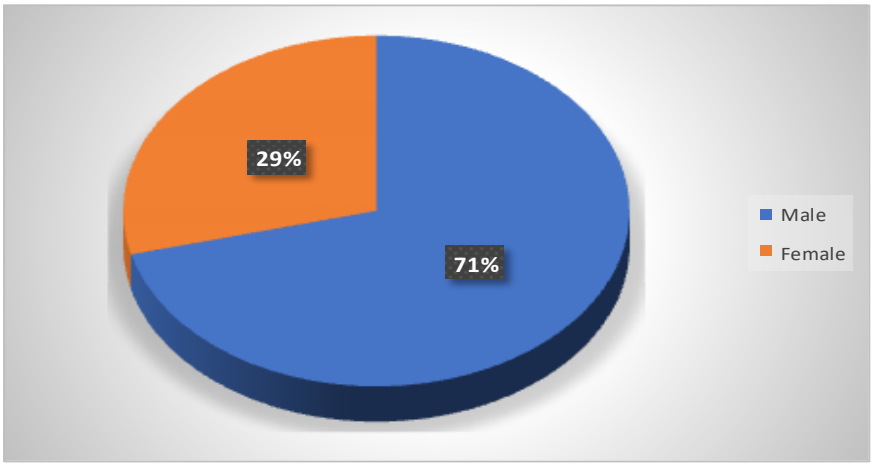

Figure 4.1. Gender of the Respondents

Source: Field data, 2024

Figure 4.1 shows that 71% of the respondents' equivalents to 51 participants were male, while 29%, equivalent of 21 participants, were female. This shows that the male participants were more than female participants. The gender representation disparity is attributed to the fact that one of the respondent groups targeted in this study were the heads of households' in Gatumba Zone, and generally the Burundi society, like many other African societies, is patriarchal wherein men are the leaders of their households.

4.1.3 Age

The respondents were asked their age and their responses were as illustrated in Figure 4.2.

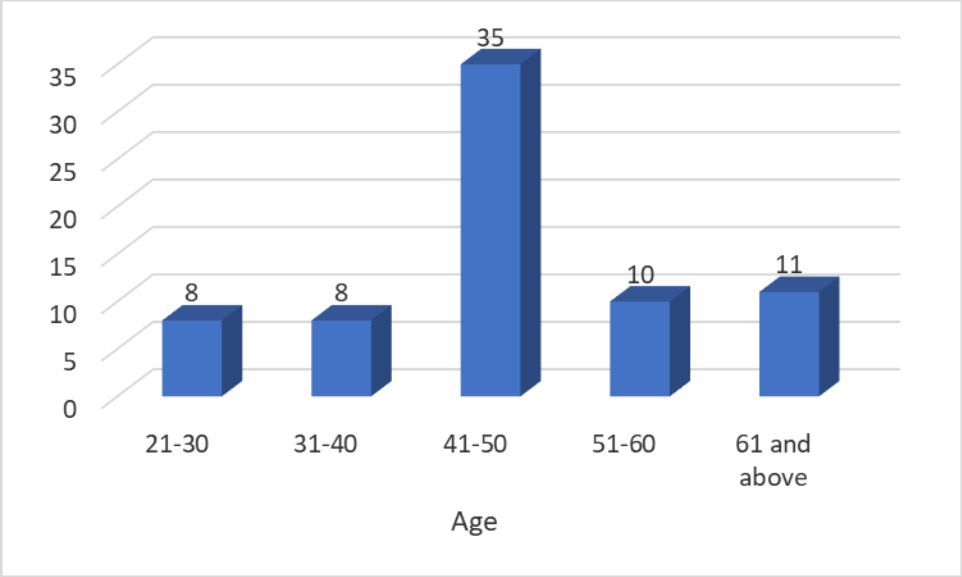

Figure 4.2. Age of the Respondents

Source: Field Data, 2024.

The age of the respondents is as shown above. 8 respondents were between the ages of 21-30 years, 8 respondents were of age 31-40 years, 35 were between 41-50 years, 10 between 51-60 and 11 respondents were in the category 61 and above years. The statistics show that majority of the participants were older adults, which means they are people who have spent many years of

their lives in Gatumba Zone, and so they can provide reliable information based on their many years of experience and knowledge on the dynamic weather conditions in the region and the impact of the changes on food security.

4.1.4 Marital Status

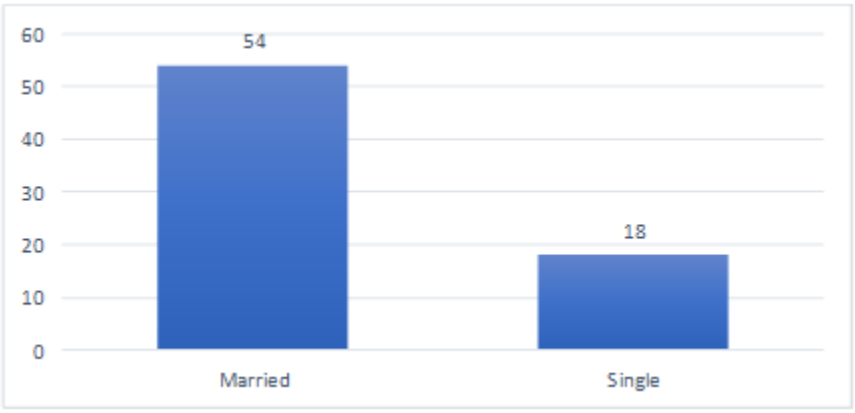

Figure 4.3 Marital Status of Respondents

Sources: Field Data, 2024

Figure 4.3 illustrates the genders of the study respondents. It was determined that 54 of them were married and 18 were single. Their diversity added to the credibility of this research because the experiences and views of both genders on the study subject were heard.

4.1.5 Level of Education

The study sought to establish the level of education of the respondents and the results are as shown by Figure 4.4.

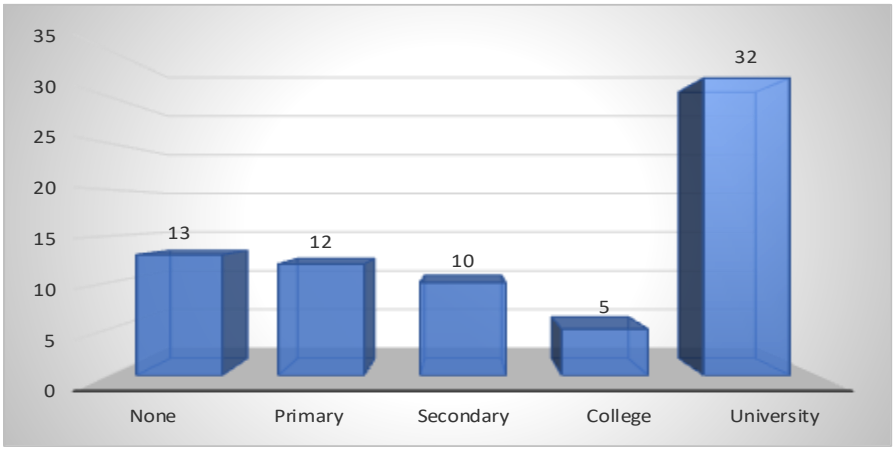

Figure 4.4 Respondents Education Level

Source: Field Data, 2024

The chart shows that 13 respondents had no educational background, 12 participants had primary level education, 5 had attained college education, while 32 respondents had university-level education. This shows that majority of participants were learned individuals, which means they were able to clearly understand the focus of this study and respond appropriately from their experience about climate variability and its impact on food security in Gatumba Zone.

4.2 Effect of Drought on Food Security in Gatumba Zone

Gebrechorkos *et al.*, (2020) explain that climate variability is a major issue in East African countries and a cause of extreme climatic events such droughts. In their study, they reported that one key indicator of this issue is the increasing trend in maximum temperatures, and because of this, droughts have become a recurring event in several countries in East Africa over the past two decades.

4.2.1 Frequency of Drought in Gatumba Zone

In order to determine how extended drought spells have affected farm productivity and consequently food security in Gatumba Zone, the study sought to establish the frequency of

droughts in the region. The study participants were asked to describe the frequency of the drought in Gatumba Zone using one of the following options: Very frequent, frequent. occasional, rare, very rare. The responses were as presented in Figure 4.5

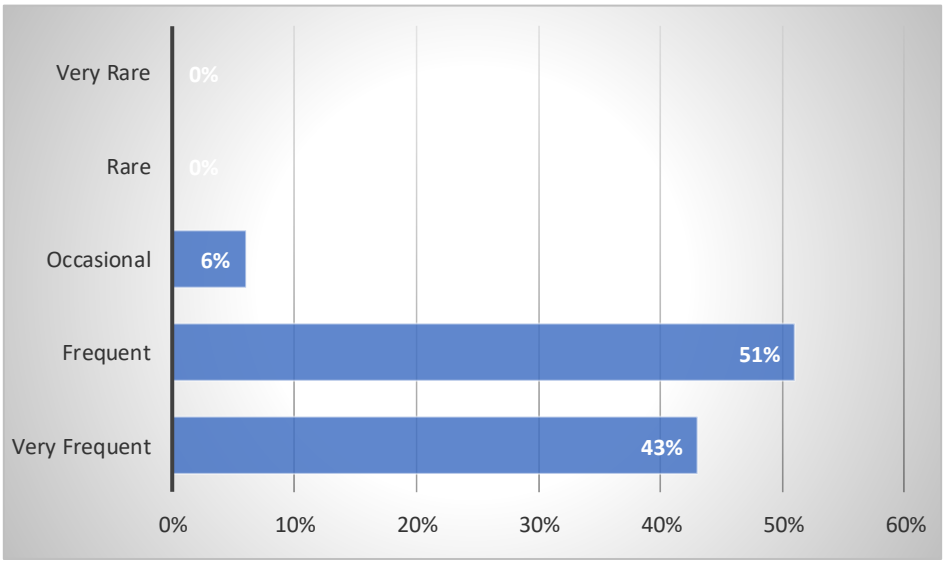

Figure 4.5 Frequency of Droughts in Gatumba Zone

Source: Field Data, 2024

The chart above shows that 43% of the respondents felt that drought spells in this area are very frequent, 51% responded that the spells are frequent, and only 6% expressed that the drought spells are occasional. None of the respondents responded as to whether they were rare or very rare. The key respondents also expressed that droughts have been a major challenge in Gatumba Zone that has been occurring yearly in the recent past. In a similar study conducted by Nkunzimana *et al.*, on drought events and trends in Burundi between 1993 and 2010, it was established that severe droughts began in Burundi in 1993 and reccurred in 2000, 2003, 2005, 2007, and 2010 (Nkunzimana *et al.*, 2021). This suggests that this hazard has gotten worse by the years. It never used to occur every year, but now it has become an annual problem for the people of Gatumba Zone.

4.2.2 Drought Impact on Farm Productivity

The study posed the following question to the respondents: Do you believe that drought is a major problem in Gatumba zone that is affecting farm productivity? Their responses were as illustrated in Figure 4.6.

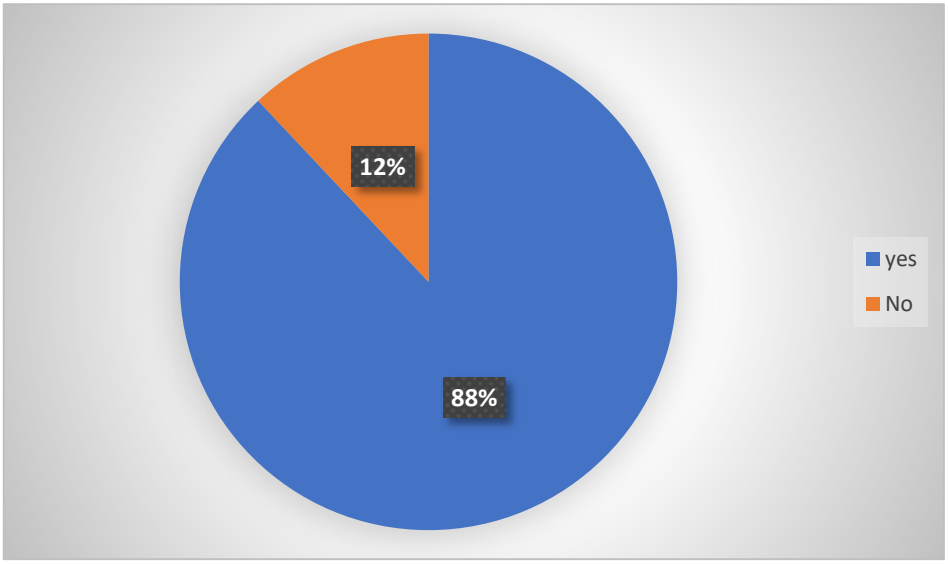

Figure 4.6: Drought Impact on Farm productivity

Source: Field Data, 2024

Figure 4.6 illustrates the participants' responses. It appears that the majority of the respondents agreed on this matter. As shown, 88% expressed that droughts are major problem affecting farm productivity in Gatumba Zone, while 12% a contrary view on this. This suggests that farmers produce less that their farm potential because of drought spells. It is also an indication that the productivity of the farms in Gatumba zone would go higher if this challenge is addressed. Some of the participants explained that in addition to the low production, the quality of harvest is also low as a result of the droughts. During the interviews a community leader opined as follows:

> The recurrence of drought affects the overall quality of yields and causes many people to face hunger because what was produced cannot sustain the daily food needs in the household for an extended period (KII 4).

It is instructive to note that at least 90% of people in Gatumba zone are subsistence farmers, and so many lives are put at risk of hanger and starvation when their farm yields decline as a result of droughts, their livelihood is threatened. This finding was consistent with that of Gebrechorkos *et al.,* (2020) who reported that agriculture in East Africa is largely rain-fed, which makes it highly vulnerable to adverse weather conditions. This means that droughts induce significant impact on agriculture sector in this region because farmers are overly dependent on rain for their farming activities.

Selective planting was also been found to be another reason for declining farm productivity during the dry spells. Asked on how drought affected the planned planting decisions, the findings were as presented in Figure 4.7

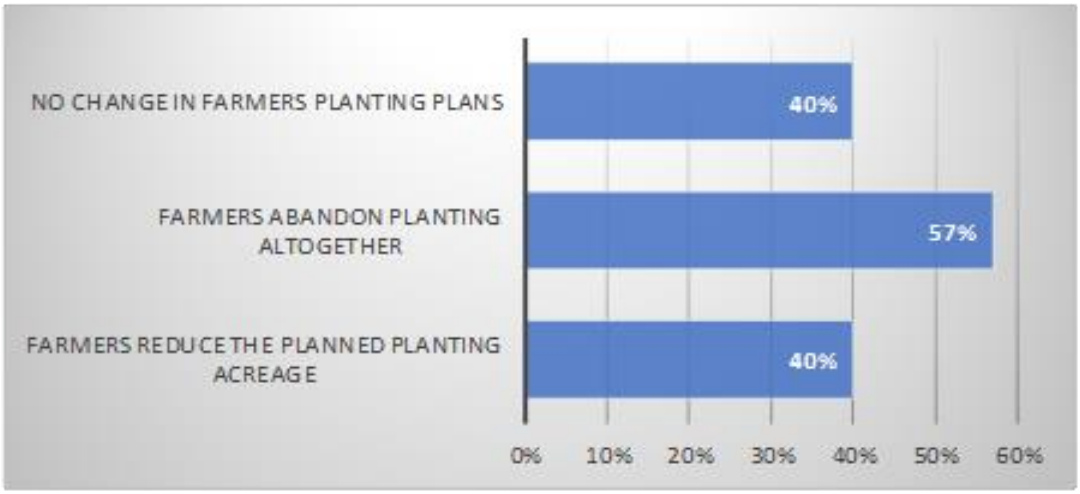

Figure 4.7 Effect of Drought on Planned Planting

Source: Field Data

Figure 4.7 illustrates the farmers' decisions upon the onset of a drought during the pre-planting stage. The results show that more than half (57%) expressed that abandoning planting plans is one of the actions that farmers take. 40% expressed that there is usually no change observed in the farmers' planting plans, and an equal number expressed that farmers end up reducing the acreage they had planned to plant. It is apparent that farmers in Gatumba Zone have differing risk perception and expectation, and those that abandon planting have the highest risk perception, followed by those who decide to reduce the planned planting acreage. The outcome is consistent with Booth *et al.,* (2020) findings who established that farmers' decisions were influenced by their risk perception and expectation. In their research they found that when farmers expect the drought to grow more severe, their planting decisions are affected, which in turn affects the overall yield. In this study, the farmers who expect the drought to grow severe reported that they abandoned the planting plans entirely to avoid losses while others chose to reduce the acreage, to control or minimize the level of losses they were likely to suffer because of the projected looming drought. The study argues that these decisions informed by climate variability and especially the phenomenon of drought contribute significantly to the low level of food production in Gatumba Zone. During the interviews, one of the interviewees explained thus:

> The onset of drought disrupts many farmers' planting plans majorly because of past experiences. If they suffered losses before, then they are likely to refrain from planting or they could reduce the acreage they had prepared for planting (KII 2).

The consequence of low production arising from the decision to reduce acreage or not plant is widespread food insecurity. In 2016, Voice of America (VOA) reported that at least 600,000 people were short of food in Burundi, and they predicted that the number would be rising in the years that followed (VOA, 2016). The VOA report also mentioned that this food security problem has led to many people fleeing the villages to the urban centres in search for alternative

sources of sustenance. This finding further lends credence to the argument made by the FAD theory that droughts affect availability of food, posing challenges for vulnerable households in meeting their basic needs. The migration also reduces the number of farmers in the rural areas, and as a result, Gatumba Zone and the wider Burundi becomes more food insecure.

4.3 Extent that Floods Affect Food Security in Gatumba Zone.

This subsection of the study focused on establishing the impact that floods had on food security in Gatumba Zone. This was against the understanding that crop growing in Burundi is heavily dependent on rain fed agriculture, thus it is important to determine the impact that floods have on this sector.

4.3.1 The Challenge of Flooding in Gatumba Zone

The agriculture sector contributes around 30% of the GDP in Burundi, meaning a vast majority of the population are involved in some agricultural activity of some sort (UNEPGRID, 2014. Primarily conducted on small scale, agriculture in Burundi is highly dependent on favourable weather conditions for it to thrive. Climatic hazards therefore present a significant risk to agricultural production. This objective sought to establish the extent to which floods affect agriculture and consequently food security in Gatumba Zone. To establish the prevalence of flooding in Gatumba Zone, the respondents were asked whether they had noticed an increase in the frequency of floods in Gatumba Zone in recent years. Instructively, 100% of the respondents affirmed that floods had become more frequent. This view was corroborated by the Key Informant Interviewees who also described flooding in Gatumba Zone as a serious crisis that had destroyed farmland, homes and infrastructure. KII 1 noted the following:

> Gatumba zone has experienced flooding annually in the last ten years or so. The flooding has had devastating effect on the agriculture sector as farmland has been destroyed; crops washed away as well as animals and peoples' homes. I believe the destruction of crops due to the flooding has contributed to the food security challenges that the country has been going through lately. (KII 1)

The responses concur with what has been widely reported about the flooding problem in Burundi. The flooding in Gatumba Zone has been attributed to the breaking of the banks of River Rusizi which traverses the area. This phenomenon leaves many families devastated. The International Federation of Red Cross' (IFRC) statistics on the number of people that were affected by floods in the various villages in Gatumba Zone in May 2018 were as shown in Table 4.2.

Table 4.2 Villages and People Affected by Floods in May 2018

Villages	Number of affected people			Total affected people
	Men	Women	Children	
Gaharawe	355	321	1384	2060
I Mushasha	237	234	1101	1572
Mushasha II	391	377	1740	2508
I Muyange	121	124	333	578
Muyange II	276	387	936	1599
I Kinyinya	189	202	944	1335
Kinyinya II	188	184	888	1260
Warubondo	201	204	337	742
Vugizo	185	225	892	1302
TOTAL	**2143**	**2258**	**8555**	**12956**

Source: IFRC, 2018.

Table 4.2 shows that in May 2018, floods affected 12,956 people living in the villages in Gatumba Zone (IFRC, 2018). In 2020, the International Organization of Migration (IMO) also

reported startling figures about the effect of the severe floods that occurred in Gatumba Zone in May 2020. According to the reports, the most affected villages by the floods were Gaharawe, Kinyinya I, Kinyinya II, Mushasha I, Mushasha II, Muyange I, Muyange II. The report also indicated that these floods affected about 45,681 people, which is almost four times the number of those affected by the 2018 floods (IOM, 2020). This is an indication that the floods in Gatumba Zone are getting worse and so are their repercussions on the people. In April 2023, Gatumba Zone was once again hit by severe flash floods that affected thousands of households and resulting in extensive destruction (Irakoze, 2023). The displacement of the people by the floods means that they cannot meaningfully engage in agriculture and this affects food production, effectively undermining food security.

4.3.2 Effects of Floods on Farms in Gatumba Zone

Extreme weather conditions can have destructive effects on crops. Thus, this study inquired from the study participants about effects of floods observed on the farms. Their responses were as illustrated by Figure 4.8.

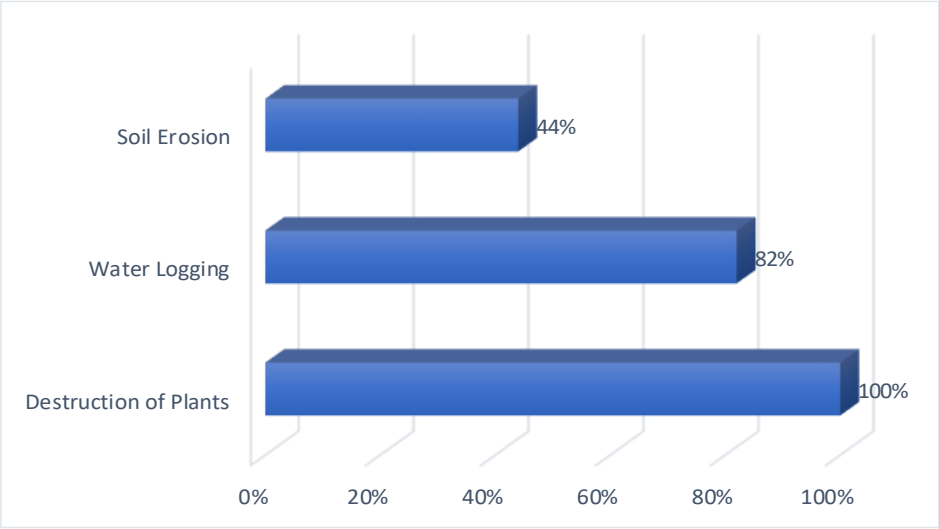

Figure 4.8 Effects of Floods on Farms in Gatumba Zone
Source: Field Data, 2024

Figure 4.8 shows that all respondents agreed that floods destroy plants. 82% agreed that the other destructive effect of floods on farms in Gatumba Zone is water logging. 44% confirmed soil erosion as the other effect on the farms in Gatumba Zone following floods. Water logging is a serious threat to crop productivity. It leads to the saturation of soil pores, which reduces the availability of oxygen to the plants' roots. Like all other aerobic organisms, plants require oxygen for cellular respiration. Without sufficient oxygen, root cells cannot produce energy efficiently, leading to decreased metabolic activity and growth. Prolonged exposure to waterlogged conditions can also cause root damage and decay. Roots may become waterlogged themselves, leading to the development of root diseases. Damaged roots are also less efficient at absorbing water and nutrients, further exacerbating stress on the plant. Therefore, crops under such conditions often exhibit stunted growth and poor development. Additionally, waterlogged soils create favorable conditions for the growth of fungal pathogens and other disease-causing organisms.

Floods cause soil erosion because the sheer velocity of the water dislodges soil particles and carry them downstream. Floodwaters scour the soil surface and streambeds, removing layers of soil and sediment. As the water flows over the land, it picks up loose soil particles and transports them downstream. Soil erosion has detrimental effects on crops because it often results in the loss of the fertile topsoil layer, which is rich in organic matter and nutrients essential for plant growth. Topsoil loss therefore reduces soil fertility and productivity, making it more challenging for crops to obtain the nutrients they need for healthy growth. Erosion can also disrupt soil structure, leading to compaction, crusting, and decreased water infiltration and retention. The study determined that crops such as maize, beans, Amaranth, sweet potatoes, tomatoes are the most affected when floods occur in Gatumba Zone.

Niyongabo (2023) conducted a study about the effects that flood had on the 2023 harvest in Gatumba Zone. Residents of this community were interviewed and some of them expressed that they had a bad harvest because their crops had been washed away by the floods. Another resident explained that farms had become water logged and this reduced the area intended for agriculture. In this study, an interviewee used exactly the same words as a KII reported in Niyongabo's study who reported that. "We no longer cultivate on the water logged parts of our farms and the harvest has diminished". It was also determined that flooding had contributed to emergence of pests, such as armyworms that were also destroying the crops. Therefore, as articulated by the FAD theory, floods too, similarly to drought, affect crop production and this has a direct effect on food security.

4.3.3 Displacement of Farmers

Asked whether flooding had occasioned displacement of farmers, 100% of the respondents responded in the affirmative. These findings are corroborated by Kakinuma *et al.*, (2020) who carried out a similar study where they established that floods cause displacement of populations. A case example is the flooding that occurred in Gatumba Zone in May 2018. It destroyed several houses and many others were flooded as showed by Table 4.3.

Table 4.3 House Destroyed by Floods in Gatumba Zone in May 2018

City	Houses totally destroyed	Houses partially destroyed	Houses flooded	Total
Gaharawe	40	51	256	347
Mushasha I	87	105	27	219
Mushasha II	116	177	129	422
Muyange I	81	38	10	129
Muyange II	19	16	259	294
Kinyinya I	65	109	24	198
Kinyinya II	79	57	49	185
Warubondo	10	19	120	149
Vugizo	7	16	167	190
TOTAL	504	588	1041	2133

Source: IFRC, 2018

Table 4.3 illustrates that a total of 504 houses were totally destroyed in 9 villages in Gatumba Zone, 588 were partially destroyed and 1,041 were flooded. The level of destruction varied, but the most affected were Mushasha II and Gaharawe. Majority of the families whose houses were destroyed were forced to relocate to safer areas. One of the interviewees expressed the devastation of having to leave their home because of floods. She said:

> Because of the flooding, I have been forced to move. All our houses were destroyed and our families forced to live as internally displaced people. (KII 2)

The displacement of households as a result of floods has become a persistent problem in Gatumba Zone. IOM reported that the floods that hit this region in May 2020 resulted in the displacement of 17,792 people. The demographics of the persons displaced is in that year was as shown in Figure 4.9

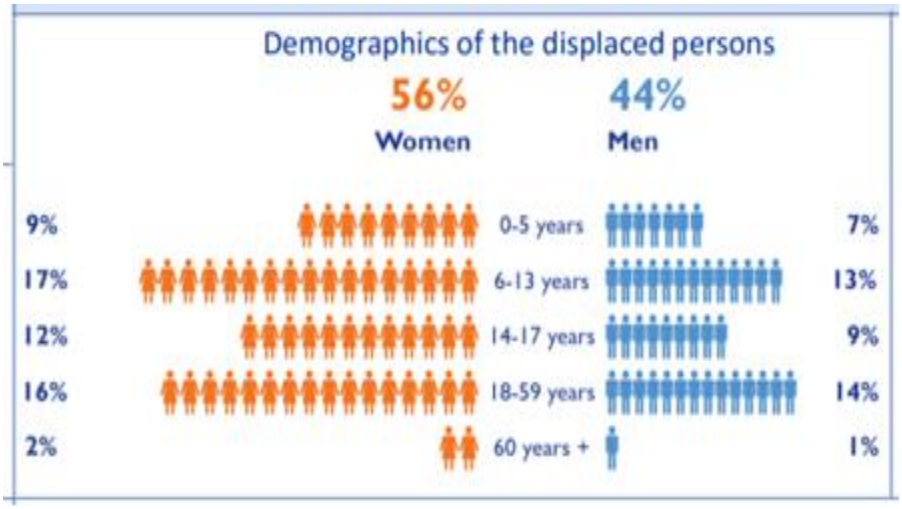

Figure 4.9. The Demographic of Displaced Persons in Gatumba Zone During 2020 Floods

Source: IOM, 2020

Figure 4.9 shows that majority of the men who were displaced were between the ages of 18-59 years and this age category was among the highest group of the internally displaced women as a result of floods. The people in this age category are among the most productive in a society, and since majorities are farmers, displacement forces them to abandon their farming activities to the detriment of food security. Sana (2023) conducted a study on the displaced persons following the April 2013 floods in Gatumba Zone. One of the internally displaced persons who were interviewed during this study expressed that he was forced to flee his home together with his family for the third time since 2019. Among the displaced persons, those unable to construct new houses or restore their old houses are forced to live in emergency shelters. When people are displaced, it means reduction in food production, which has cascading effects on sustainability of food systems. According to Food and Agricultural Organization (FOA), when people are forced to flee their homes, they lack access to land and so they are less able to cultivate food (FAO, 2024).

Displacement also forces some farmers to find alternative sources of earning a livelihood other than farming. During the interviewees, one of the respondents noted that:

> As a result of floods, the entire community of Gatumba is languishing in immeasurable poverty…Our group has decided to put more effort into a *small business*. (KII 6)

Another interviewee expressed their concern as follows:

> We are looking for several benefactors to increase our capital to set up a large business. (KII 3)

This is a clear indication that floods discourage farmers from farming and they start venturing in other businesses. This adversely affects the food supply in the communities. To confirm that this was happening in Gatumba Zone, the participants were asked to describe the extent to which floods had affected the availability of food in Gatumba Zone. Their responses were as shown in Figure 4.10.

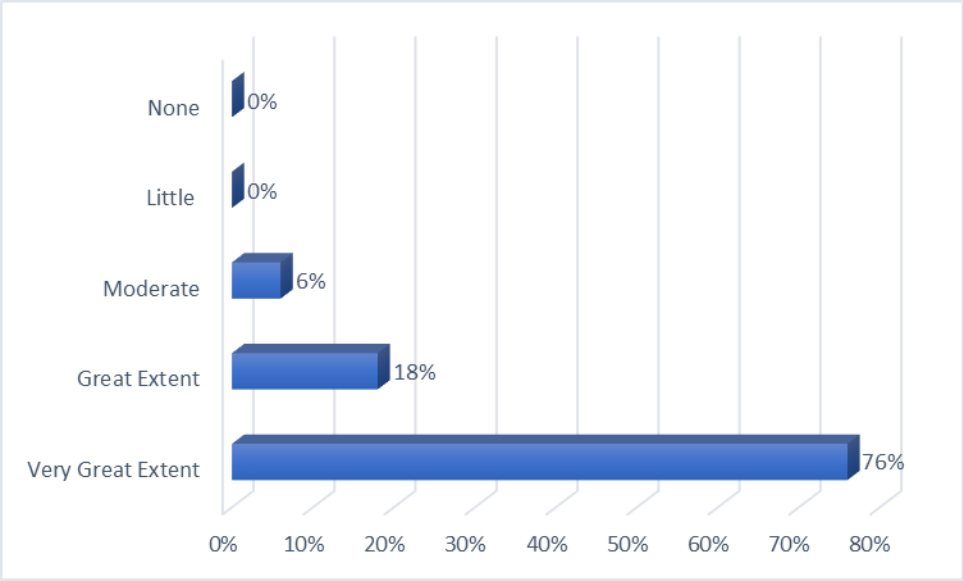

Figure 4.10 Floods and Food Availability in Gatumba Zone

Source: Field Data, 2024

Figure 4.10 illustrates the responses provided by the study participants about the effects of flood on food availability in Gatumba. Majority (76%) expressed that floods have affected food availability to a very great extent, 18% responded that the food availability has been affected to a great extent, and 6% expressed that the effect is moderate. From these findings, it is evident that floods have had adverse effects in Gatumba Zone including, destroying crops, soil erosion, displacement of the agricultural workforce, thus affecting the overall performance of the agricultural sector which manifests through low food supply and the increased prices of food commodities, thus undermining food security.

4.4 Coping Strategies Practiced by Farmers to Address Climate Variability and Enhance Food Security in Gatumba Zone.

Climate shocks create volatility in agricultural production. All the respondents in this study agreed droughts and floods have been a cause of food shortage in Gatumba zone. The Integrated Food Security Phase Classification (IPC) also presents the evidence on the status of food security in Burundi. The 2021-2022 food insecurity analysis reported that climate hazards were behind the food insecurity in Burundi (IPC, 2021). This report indicated persistent floods as the major factor contributing to food insecurity in Burundi. Thus, the study sought to determine the strategies adopted by farmers to overcome the challenges posed by climate variability and meaningfully contribute to food security in the country.

4.4.1 Climate Resilient Strategies Utilized by Farmers in Gatumba Zone

In light of the consequences of drought and floods on agriculture, it was necessary to establish the coping strategies that farmers in Gatumba Zone practice to enhance resilience and curtail the effects of these hazards on food production. This question was informed by the ToC theory's

advocacy for transformative actions to enhance resilience against climatic shocks. The respondents were presented with a list of adjustments commonly used, and asked to identify those being applied by farmers in Gatumba Zone. Their responses were as presented in Figure 4.11.

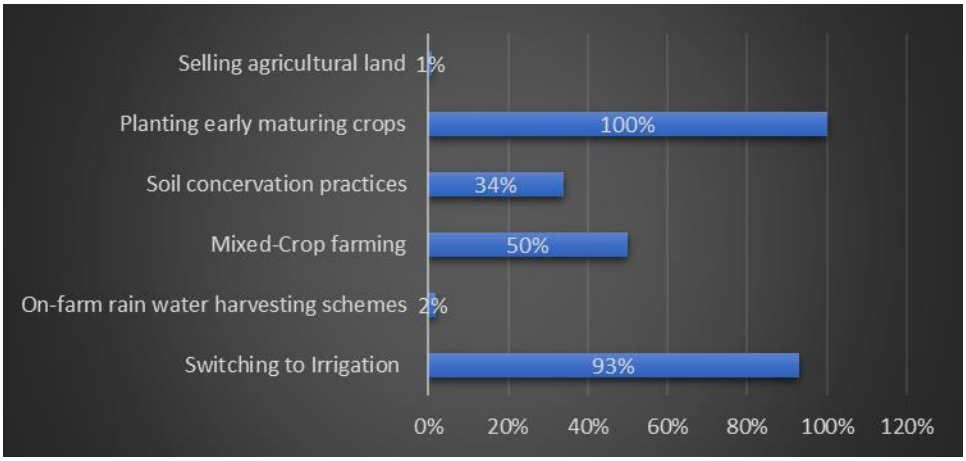

Figure 4.11: Responses on Strategies Employed to Enhance Resilience to Climate Hazards in Gatumba Zone

Source: Field Data

As shown in Figure 4.11, the most popular coping strategy that farmers were using was planting of early maturing crops and switching to irrigation as reported by 100% and 93% of the respondents respectively. Mixed crop farming and soil conservation practices were also found to be used as reported by 50% and 34% respectively of the respondents. The study also established that at least 2% of the farmers farmers engaged in on-farm rain water harvesting to especially guard against the frequent droughts in the study area. Incidents of farmers reacting to the unfavourable weather conditions in Gatumba Zone by selling off their agricultural land were found to be very few and far between as reported by 1% of the respondents.

It was also necessary to establish the measures that so far, the government had employed to cushion farmers from the effects of floods and droughts in their farming activities. A key informant reported that.

> The government has initiated several actions to stabilize the banks of Rusizi River by planting trees all along and provided to farmers seeds that can resist the effects of droughts and floods. (KII 3)

This view was echoed by a different KII who noted that:

> For drought, farmers are encouraged to plant early maturing varieties and the government has initiated low-tech irrigation system to reduce the drought effects (KII 1).

It is evident that the state has focused more on droughts but had not done much to protect the farming activities, only by relocating the affected households. All the respondents (100%) also noted that the government of Burundi is not doing enough to cushion farmers from the effects of floods and drought. Majority mentioned that it is up to the government to implement robust measures to regulate Rusizi River water flow during the rainy seasons to prevent its overflow. A respondent mentioned that the relocation of farmers from flooding zones should be properly executed by offering them other lands where they can continue with their farming activities. A key informant held the view that:

> The government should also think of mechanisms of compensating the farmers as a morale booster for them to continue participating in agriculture. Given that flooding and drought were becoming perennial problems, such compensation would encourage farmers to hold onto the venture and thus contribute to food security, despite the challenges. (KII 4)

4.4.2 Constraints to Adoption of Climate Resilient Practices by Farmers in Gatumba Zone.

The study sought to determine the factors that limited farmers from adopting coping strategies to mitigate the effects of droughts and floods on their farms. Almost all the respondents, 97%, mentioned lack of financial resources as an impediment to adopting the appropriate methods to mitigate the effects of drought and floods. The common thread in their response was that all the mitigation measures were capital intensive, citing for example acquisition of irrigation equipment, purchase of early maturing seeds, construction of sand dams or water dams to collect the surface run off. This finding was consistent with that of Batungwanayo *et al.,* (2023) who also determined that access to funds strengthens the financial capacity of a farmer, and therefore they can easily undertake new adaptations.

Another constraint reported by 43% of the respondents was poor access to information and agricultural extension services. This study argues that information is key to help farmers understand some of the farm management practices that they can implement and also to keep them updated on weather patterns. Such information coupled with the extension services can support farmers' decision making so that the country's food security capability is not adversely affected. Other constraints reported by the respondents include the size of farm land as not being adequate due to land fragmentation as well as experience among the farmers. Farm size denotes the total land area owned by a farmer's family and can serve as an indicator of wealth, facilitating the family's ability to adapt to climate variability. Land size affected adaptation options such as mixing crops, soil conservation, and shifting farming systems in that, for small holdings, a farmer may be unable to apply some of the reasonable practices that may support food security. An experienced farmer was reported as being more likely to adopt adaptation strategies such as implementing crop rotation.

4.5 Chapter Summary

Droughts have grown more frequent in Gatumba Zone in recent years. In a country where majority of farmers practice rain-fed agriculture, droughts affect farm productivity. Water deficit affects crop productivity, which results are lower crop yield and also low-quality produce. It was determined in this analysis that droughts also influence selective planning among farmers, in that farmers with high threat perception refrain from planting if they believe that a drought spell will grow more severe in the future. Others, reduce the acreage they had planned for planting. A combination of these factors makes the region even more food insecure.

The torrential rains in Gatumba Zone are to blame for the floods. When they occur, plants are destroyed and the soil erosion depletes the farms nutrients. Another consequence is that farmers end up relocating to other areas and leave their farms or they flee to urban areas in search other means of earning income other than farming. These too contribute to lowering the amount of food produced, exacerbating food insecurity in Gatumba Zone and Burundi in general. The climate resilient strategies that some farmers in Gatumba Zone are using include switching to irrigation, planting early maturing crops, mixed crop farming, and soil conservation practices. It was also realized that reasons that the majority are yet to implement these coping measures is because of a lack of financial resources, poor access to information and lack of extension services, farm size and years of experience as a farmer.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter consists of the summary of findings, conclusion, and the recommendations by the researcher. The study subject was climate variability and food security in Gatumba Zone; Burundi.

5.1 Summary of the Key Findings

The summary is organized according to the study objectives: Effects of drought on farm productivity in Gatumba Zone; extent that floods affect agriculture in Gatumba Zone; coping strategies practiced by farmers to address climate variability challenges in Gatumba zone.

5.1.1 Effect of Drought on Food Security in Gatumba Zone

Majority of East African countries rely on rain-fed agriculture. Today, this sector has been greatly affected because of the extended drought spells that have grown more frequent in recent years. Burundi being one of the East African states, in order to establish how climate variability has affected food security, there was a need for a comprehensive study on the impact of drought on farm productivity. It was clearly established that drought is one of the climate hazards that Gatumba Zone is facing. Using responses from the study participants and information from other credible secondary sources, the study proved that drought is no longer a sporadic events in this country as it were one decade ago, but have become frequent. In Gatumba Zone, drought occurs yearly.

The study then focused on determining how farm productivity in Gatumba Zone has been affected by drought. It was established that, because of water deficit in plants during a drought

spell, the crop yield reduces and also poor-quality produce is harvested. Another way by which the impact of droughts on farm productivity was explored was through the lens of farmer's risk perception and expectation which can be influenced by the pre-planting conditions. In this case, farmers who believe that an ongoing drought spell would grow worse is considered as one with a high risk perception and because of this, they can abandon the planting plans entirely for that season or they reduce the planned planting acreage. Those with low-risk perception do not change their planting plans. By choosing not to plant or to reduce the acreage, it affects the quantity of food produced, and this makes Gatumba Zone more food insecure. It was also noted that farmers past experiences with unfavorable pre-planting conditions also into play when making planting decision. The resultant food shortage that occurs because of reduced crop productivity and declined farming activities during droughts ends up affecting many vulnerable households. It was established that some of the affected persons end up freeing the villages in search for other sources of sustenance, which reduces farming activities in this region further.

5.1.2 The Extent that Floods Affect Food ASecurity in Gatumba Zone

Majority of the households in Gatumba Zone are farmers practicing small-scale farming. It was determined that various crop vulnerabilities are linked to flooding including crop damage, pest and diseases. In studying the extent that floods affect agriculture in Gatumba Zone, firstly, it was established that flooding is the most significant climatic hazard being experienced in Gatumba Zone. The floods have been getting more severe with each passing year and have become cause of devastation for many households. It was determined that Rusizi River increases during torrential rains, breaks it banks thereby flooding the villages in Gatumba Zone. In order to find out the extent that agriculture in Gatumba Zone is affected by floods, two perspectives were explored. Firstly, the effect of the floods on the farms were explored. It was determined that

floods destroy crops, and cause water logging and soil erosion. The floods wash aways the crops. In the farms where there is water logging, the prolonged exposure to waterlogged conditions decreases the plants metabolic activities, causes root damage and consequently, crops decay. The water-logged soils also create favorable conditions for pathogens and diseases that attack surviving crops. Floods also result in soil erosion which is also detrimental to crops growth because the land is stripped off of the nutrients essential for crop growth. The destruction of crops, the waterlogged farms and soil erosion adversely affect agriculture performance in Gatumba Zone.

The second way by which the effect of floods on agriculture was explored in this study was by exploring the role it plays in the displacement of farmers from their lands. The study established that thousands of people in Gatumba Zone are displaced every year from their homes because their houses are either totally destroyed by the floods, partially destroyed or because they are flooded. It was determined that some villages are affected more than others, and families are forced to relocate to other areas where they live in temporary shelters. The displacement of the people is detrimental to agriculture, because majority are farmers, and because of the floods, they are forced to abandon their homes and their farmings, which further affects Gatumba Zone's food security. Some of the displaced farmers even resort to other income generating activities, including opening small businesses.

5.1.3 Climate Variability Coping Strategies Practiced by Farmers to Enhance Food Security

Food shortage was confirmed a reality in Gatumba Zone because droughts and floods reduce the quantity of food produced by farmers and it also disrupts agriculture. In light of this, the study undertook to determine the coping strategies that are being employed in Gatumba Zone to

enhance resilience against the climatic hazards and to curtail the adverse effects they have on food security in Gatumba Zone. It was determined that one of the strategies that farmers use is planting early maturing crops. These help the farmers to evade droughts and floods because they can yield a positive harvest within a short period of planting. Another coping mechanism used by farmers in Gatumba Zone is irrigation. This reduced farmers' reliance on rains. Other solutions that have been observed are mixed-crop farming, and soil conservation practices.

In addition to the individual coping strategies, the study also assessed the mechanisms that the Government of Burundi has put in place to aid farmers overcome the challenges of drought and flooding. The study established that some of the actions taken by the state are planning of trees along the banks of Rusizi River to prevent it from overflowing during the rains. The state has also been supplying farmers with drought resistant seeds, providing farmers with low-tech irrigation systems. Despite the effort Gatumba Zone residents consider them insufficient and they need strategic solutions. Considering that there is limited adoption of coping strategies to address climate variability challenges in Gatumba Zone, the constraints identified were inadequate financial resources, poor access to information and lack of agricultural extension services, size of the farm, and years of experience in farming.

5.2 Conclusion

The study used both primary and secondary data to study climate variability and food security in Burundi, using Gatumba Zone as the location of focus. The findings indicate that Burundi has experienced frequent and severe drought over the last three decades which have negatively impacted farm productivity and consequently food security. Apart from the high temperature affecting crop performance because of water deficit, it was also apparent farmers' decision about planting were also affected by the adverse pre-planting conditions, which in turn contributes to

declining farm productivity, hence food insecurity. This is because, at the onset of drought, some farmers' abandon their planting plans altogether for that season, or reducing the acreage they had planned to plant. Such actions contribute to higher food insecurity.

The study also presents valuable insight on the extent to which floods affect food security in Gatumba Zone. The effect of floods on farmland is profound in terms of destructive power of water on the crops, the soil, and farmers' access to farmland. It is clear that the displacement of farmers from their homes hinders participation in farming activities. These repercussions end up affecting the quality and quantity of food that is produced across the area of study and beyond. Farmers are the owners of human capital, but when floods occur, thousands of farmers are displaced from their lands and their homes to live in temporary shelters. This means that their farming activities are interrupted and the overall production declines. Frequent displacements also push some farmers to venture into other businesses instead of farming, and this too reduces the overall production of food in Gatumba Zone, thus undermining food security.

Climate variability coping strategies that were being utilized by farmers in Gatumba Zone to enhance resilience against adverse weather conditions were diverse. There were however two mechanisms that were popular with the farmers: planting of early maturing crops and the resort to irrigation especially during the dry spells. It was also clear that many farmers in Gatumba zone had not embraced the coping strategies to enhance resilience against floods and droughts, mostly due to lack of financial resources as well as the requisite knowledge and support system for them to produce more.

5.3 Recommendations

In light of the findings, the study makes the following recommendations:

5.3.1 Academic

There ought to be an exhaustive investigation on the overflow of River Rusizi as the major cause of flooding in Gatumba Zone. An exhaustive analysis of the destruction it has caused on homes and farmlands is needed in order to inform the mitigation measures that can be proposed to combat the phenomenon. Moreover, the research should aim at recommending the policy options that the government can take to reverse the adverse effects of climate variability on food security.

5.3.2 Policy Recommendations

To prevent farmers from making drastic decisions such as abandoning planned planting or reducing the farming acreage, which ends up hurting the food security in the region, the government through the Ministry of Agriculture should reinvigorate the agricultural extension services to educate farmers' on methods of drought and floods tolerance. This information will help them better prepare and adjust to the attendant climate shocks.

Secondly, the Ministry of Water, Environment and Land Management should ensure timely allocation of land to displaced persons who are unable to restore their homes after floods to allow them continue with farming. This will help maintain continues production of food and curb food insecurity.

The study also proposes the establishment of an agricultural insurance mechanism that can compensate the farmers the losses that they incur in the course of food production, and especially vagaries relating to climate variability. This will make farming attractive and farmers will no longer have to count their losses whenever there are floods or droughts. It could also be an incentive to encourage more people into farming, thus boosting food security.

Finally, the Ministry of Agriculture should collaborate with financial institutions to address the funding constraints by availing credit to farmers at low costs, provide farms inputs, such as drought resistant seeds at subsidized prices and also collaborate with the media houses to ensure regular dissemination of weather forecasts, and agronomic and climate information that can enhance the farmers' levels of preparedness.

5.3.3 Areas for Further Research

Additional research is essential to clarify the connection between climate change and economic security. The study would highlight the intricate relationship between climate variability and economic stability, particularly because this analysis has shown that Burundi seems to lack sufficient mechanism to address the climate variability impacts on food security, which means the economic security of the people, is also affected.

BIBLIOGRAPHY

Ahmed, M., Wadud, A., & Ga`al, H. (2023). The Impact of Drought on Agricultural Production in Jowhar, Somalia. *Journal of Economics and Development Studies, 11*(1), 55-62. DOI: 10.15640/jeds.v11n1a6.

Ajay, K., & Pritee, S. (2013). Impact of climate variation on agricultural productivity and food security in rural India. *Economics Discussion Papers, No. 2013-43*.

Atubiga, J. A., & Donkor, E. (2022). Empirical literature review on the menace of floods on food security. *Journal of Social Sciences*, *18*(1), 136-148. doi:10.3844/jssp.2022.136.148

Batungwanayo, P., Habarugira, V., Vanclooster, M., Ndimubandi, J., F. Koropitan, A., & Nkurunziza, J. D. (2023). Confronting climate change and livelihood: Smallholder farmers' perceptions and adaptation strategies in northeastern Burundi. *Regional Environmental Change, 23*(1). doi:10.1007/s10113-022-02018-7

Belloumi, M. (2014). Investigating the Linkage Between Climate Variables and Food Security in ESA Countries. *Regional Environmental Change, 172-186*.

Booth, P., Walsh, P. J., & Stahlmann-Brown, P. (2020). Drought intensity, future expectations, and the resilience of climate beliefs. *Ecological Economics, 176*, 106735. https://doi.org/10.1016/j.ecolecon.2020.106735.

Bowbrick, P. (2022). *Entitlement and food availability decline(FAD) – the use of fraud and abuse in famine economics*. Retrieved from MPRA website: https://mpra.ub.uni-muenchen.de/115162/1/MPRA_paper_115133.pdf

Campbell, B. M., Hansen, J., Rioux, J., Stirling, C. M., Twomlow, S., & (Lini) Wollenberg, E. (2018). Urgent action to combat climate change and its impacts (SDG 13): Transforming agriculture and food systems. *Current Opinion in Environmental Sustainability, 34*, 13-20. https://doi.org/10.1016/j.cosust.2018.06.005.

Caritas. (2022). Mali in desperate need of emergency food and nutritional aid as severe droughts persist in the Sahel. *ReliefWeb*. https://reliefweb.int/report/mali/mali-desperate-need-emergency-food-and-nutritional-aid-severe-droughts-persist-sahel.

Carr, E. R., & Thompson, M. C. (2014). Gender and climate change adaptation in agrarian settings: Current thinking, new directions, and research frontiers. *Geography Compass*, 8(3), 182-197.

Crowe, S., K. Cresswell, and A. Robertson. "The Case Study Approach." *BioMed Central*. Last modified June 27, 2011. https://doi.org/10.1186/1471-2288-11-100.

Dasgupta, S., Hossain, M. M., Huq, M., & Wheeler, D. (2014). *Climate change, soil salinity, and the economics of high-yield rice production in coastal Bangladesh*. Policy Research Working Paper 6862, World Bank.

Datta, P., Behera, B., & Rahut, D. B. (2022). Climate change and Indian agriculture: A systematic review of farmers' perception, adaptation, and transformation. *Environmental Challenges, 8*, 100543. https://doi.org/10.1016/j.envc.2022.100543.

Deressa, T. T., Hassan, R. M., & Ringler, C. (2008). M*easuring Ethiopian farmers' vulnerability to climate change across regional states*. IFPRI Discussion Paper 00798.

Devereux, S. (2007). The impact of droughts and floods on food security and policy options to alleviate negative effects. *Agricultural Economics*, 37(s1), 47-58.

Dinesh, D., Hegger, D. L., Klerkx, L., Vervoort, J., Campbell, B. M., & Driessen, P. P. (2021). Enacting theories of change for food systems transformation under climate change. *Global Food Security, 31*, 100583. https://doi.org/10.1016/j.gfs.2021.100583.

Downing, T. (1992). Climate Change and Vulnerable Places: Global Food Security and Country Studies in Zimbabwe, Kenya, Senegal, and Chile. *Research Paper No. 1*. Environmental Change Unit, University of Oxford, Oxford, United Kingdom.

Dubey, S., Shukla, M. K., Ojha, R. N., Tiwari, S. K., Mishra, R. K., & Pandey, S. K. (2012). Cause and effect of climate variability and their various impacts. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, *1*(4), 36-39. doi:10.9790/2402-0143639.

FAO. (2008). *Kenya: Food Security Brief*. https://www.fao.org/3/al936e/al936e00.pdf.

FAO. (2022). *UN report: Global hunger numbers rose to as many as 828 million in 2021*. www.fao.org.

FAO. (n.d.). FAO emergency and resilience. Retrieved from https://www.fao.org/emergencies/our-focus/forced-displacement/q-a--forced-displacement/en#:~.

FAO. (n.d.). Research and extension. Retrieved from https://www.fao.org/research-and-extension/en/

Fonseca, A. H., Sediyama, G. C., Martins, S. V., Santos, C. A., & de Oliveira, A. C. (2016). Impacts of climate variability and extreme weather events on agriculture in Brazil. Climatic Change, 139(1), 93-109.

Funk, C., Hoell, A., Shukla, S., Husak, G., Michaelsen, J., Liebmann, B., ... & Lyon, B. (2015). Recent drought tendencies in East Africa and the Greater Horn of Africa. *Environmental Research Letters*, 10(12), 125004.

Galwab, A. M. (2013). *Assessing the Impact of Climate Change on Food and Nutrition Security at Household Level in Garba Tulla Sub-County* (Master's thesis). Retrieved from http://erepository.uonbi.ac.ke/bitstream/handle/11295/101175/Armara_Assessing%20the%20Impact%20of%20Climate%20Change%20on%20Food%20and%20Nutrition%20Security%20at%20Household%20Level%20in%20Garba%20Tulla%20Sub-county.pdf?sequence=1&isAllowed=y.

Gebrechorkos, S. H., Hülsmann, S., & Bernhofer, C. (2020). Analysis of climate variability and droughts in East Africa using high-resolution climate data products. *Global and Planetary Change, 186*, 103130. https://doi.org/10.1016/j.gloplacha.2020.103130.

Gupta, A. S., Amirthanathan, G. E., Pattnayak, A., & Kumar, S. (2019). Climate change impact on agricultural productivity in India: the role of adaptation strategies. *Environmental Science and Pollution Research*, 26(16), 16404-16417.

Haraldsen, T. (2023). Flood damage on agricultural land and methods for restoration of agricultural soils after catastrophic floods in cold areas. *Flood Risk in a Climate Change Context - Exploring Current and Drivers*. https://doi.org/10.5772/intechopen.109111.

Holupchinski, E., Berríos, N., Gould, W., & Fain, J. (2017). Drought impacts to crops in the U.S. Caribbean. *USGS.gov | Science for a changing world*. https://www.usgs.gov/programs/climate-adaptation-science-centers/drought-impacts-crops-us-caribbean.

Howden, J. (2000). Carbon sequestration in Australia‟s rangelands.Proceedings workshop. *Management options for carbon sequestration in forest, agricultural and rangeland ecosystems*.

Hussain, A., Memon, J. A., & Hanif, S. (2020). Weather shocks, coping strategies and farmers' income: A case of rural areas of district Multan, Punjab. *Weather and Climate Extremes, 30*, 100288. https://doi.org/10.1016/j.wace.2020.100288.

Hussain, S., Azam, M., & Raza, A. (2020). Climate change and adaptation strategies: A review of literature. *Pure and Applied Biology*, 9(4), 1361-1370.

IFAD. (2023). *Investing in rural people in Angola*. Retrieved from https:///www.ifad.org/documents/38714170/39972426/Investing+in+rural+people+in+Angola_e.pdf/5cf5166a-68c3-4d84-bfef-51e961a80ff7#.

IFRC. (2018). Emergency Plan of Action (EPoA) Update Burundi: Floods in Gatumba. Retrieved from IFRC website: https://reliefweb.int/report/burundi/burundi-floods-gatumba-emergency-plan-action-epoa-update-dref-n-mdrbi014

IOM. (2020). Flash Info: Gatumba Floods. International Organization for Migration-Burundi.

IPC. (2021). Burundi. Retrieved from https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Burundi_Acute_Food_Insecurity_2021Jun2022Mar_Summary_English.pdf.

IPCC. (2019). *Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*.

Irakoze, K. B. (2023). IOM empowering flood-displaced communities in Burundi to rebuild... Retrieved from https://eastandhornofafrica.iom.int/stories/iom-empowering-flood-displaced-communities-burundi-rebuild-their-lives.

Kakinuma, K., Puma, M., Hirabayashi, Y., Tanoue, M., Baptista, E., & Kanae, S. (2020). Flood-induced population displacements in the world Kaoru Kakinuma. *Environmental Research Letters, 15*(12). DOI 10.1088/1748-9326/abc586.

King, A. D., Pitman, A. J., Henley, B. J., Ukkola, A. M., & Brown, J. R. (2020). The role of climate variability in Australian drought. *Nature Climate Change, 10*(3), 177-179. doi:10.1038/s41558-020-0718-z

Kogo, B. K., Kumar, L., & Koech, R. (2020). Climate change and variability in Kenya: A review of impacts on agriculture and food security. *Environment, Development and Sustainability, 23*(1), 23-43. https://doi.org/10.1007/s10668-020-00589-1.

Macedo, M. N., Coe, M. T., DeFries, R. S., Uriarte, M., Brando, P. M., Neill, C., ... & Walker, W. S. (2019). Land-use-driven stream warming in southeastern Amazonia. *Philosophical Transactions of the Royal Society B*, 374(1788), 20180248.

Mesquita, P. S., Wittman, H., & Aroudo Mota, J. (2016). Climate variability, agricultural livelihoods and food security in Semiarid Brazil. *Sustainability in Debate, 7*, 38-51. doi:10.18472/sustdeb.v7n0.2016.18749

Milà-Villarroel, R., Homa, C., Ngo, J., Martin, J., Vidal, M., & Serra-Majem, L. (2016). Famine, Hunger, and Undernourishment. In *Encyclopedia of Food and Health*. Amsterdam, Netherlands: Elsevier Inc.

Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: Synthesis*. Island Press.

Montgomery, D. R. (2007). Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences*, 104(33), 13268-13272.

Mugwika, P. K. (2017). *Assessment of the Impacts of Climate Change and Variability on Food Security in Kenya: A case study of Kisii County* (Master's thesis). Retrieved from http://erepository.uonbi.ac.ke/bitstream/handle/11295/127466/Mugwika_Assessment%20of%20the%20Impacts%20of%20Climate%20Change%20and%20Variability%20on%20Food%20Security%20in%20Kenya-%20a%20Case%20Study%20of%20Kisii%20County.pdf?sequence=1&isAllowed=y.

Nagendra, H., Bai, X., Brondizio, E. S., & Lwasa, S. (2018). The urban south and the predicament of global sustainability. *Nature Sustainability*, 1(7), 341-349.

Neufeldt, H., Sand, I., Dietz, J., Hoang, M., Yatich, T., Lasco, R., & Noordwijk, M. (n.d.). *Climate change, climate variability and adaptation options*. Retrieved from https://apps.worldagroforestry.org/downloads/Publications/PDFS/BC11312.pdf.

Nkunzimana, A., Shuoben, B., Guojie, W., Abdallah, A. A., Sarfo, I., Zhihui, X., … Odhiambo, B. A. (2021). Assessment of drought event, its trend and Teleconnected factors over Burundi, central East Africa. doi:10.21203/rs.3.rs-259551/v1

Nshuti, A. (2018). *The Impact of Climate Change on Agricultural productivity in the Eastern African Community* [Unpublished master's thesis]. https://creativematter.skidmore.edu/econ_studt_schol/93.

Ochieng, J., Kirimi, L., & Mathenge, M. (2016). Effects of climate variability and change on agricultural production: The case of small-scale farmers in Kenya. *NJAS: Wageningen Journal of Life Sciences, 77*(1),71 78. https://doi.org/10.1016/j.njas.2016.03.005.

Ochieng, S., Otieno, C., & Ang`awa, F. (2017). Effects of Flooding on Socioeconomic livelihood of the farmers in lower Kano plains Kisumu County-Kenya. *International Journal of Novel Research in Interdisciplinary Studies, 4*(4), 8-16.

Olanrewaju, A. S., Yusuf, S. A., & Awe, O. M. (2019). Impacts of climate variability on food security and welfare among rural households in Nigeria. *International Journal of Climate Change Strategies and Management*, 11(1), 82-100.

Olayide, O. E., Ogungbenle, H. N., & Fasina, A. S. (2017). Flood vulnerability and food security: evidence from rural households in Nigeria. *International Journal of Disaster Risk Reduction*, 23, 1-9.

Peng, W., & Berry, E. M. (2019). The concept of food security. *Encyclopedia of Food Security and Sustainability*, 1-7. https://doi.org/10.1016/b978-0-08-100596-5.22314-7.

Rahman, A., Thomson, R., de Bie, K., & Khan, M. A. (2018). Sea level rise and salinity intrusion: impacts on water resources, agriculture and human health in coastal Bangladesh. *Environmental Management*, 61(3), 462-474.

Ray, R. L., Fares, A., & Risch, E. (2018). Effects of drought on crop production and cropping areas in Texas. *Agricultural & Environmental Letters, 3*(1). https://doi.org/10.2134/ael2017.11.0037.

Rowhani, P., Lobell, D. B., Linderman, M., & Ramankutty, N. (2011). Climate variability and crop production in Tanzania. *Agricultural and Forest Meteorology, 151*(4), 449-460. https://doi.org/10.1016/j.agrformet.2010.12.002.

Sana, G. (2023, September 18). De fortes precipitations en Vue : Les habitants des zones a risques craignent Le pire. Retrieved from https://www.yaga-burundi.com/2023/fortes-precipitations-habitants-zones-risques/.

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences*, *104*(50), 19703-19708. doi:10.1073/pnas.0701976104

Shetty, P. (2015). From food security to food and nutrition security: role of agriculture and farming systems for nutrition. *Current Science, 109*(3), 456-461. https://www.jstor.org/stable/24906100.

Shukla, S., Thakur, J. K., & Tiwari, K. N. (2010). Evaluation of soil erosion risk in a watershed of Madhya Pradesh, India, using GIS and remote sensing. *Environmental Earth Sciences*, 61(2), 373-385.

Tacoli, C., Bukhari, B., & Fisher, S. (2013). Urban poverty, food security and climate change. *International Institute for Environment and Development*. https://www.jstor.org/stable/resrep01286.7.

UN. (2022). *Drought In Numbers 2022*. https://www.unccd.int/sites/default/files/2022-05/Drought%20in%20Numbers.pdf.

UNEPGRID. (n.d.). Climate change / Burundi. Retrieved from https://dicf.unepgrid.ch/burundi/climate-change#section-drivers.

UNHCR. (2022). *UNHCR, the UN Refugee Agency*. https://www.unhcr.org/news/briefing-notes/millions-face-harm-flooding-across-west-and-central-africa-unhcr-warns.

UNICEF. (2023). *Angola*. https://www.unicef.org/media/131461/file/2023-HAC-Angola.pdf.

Vernooy, R. (2022). Does crop diversification lead to climate-related resilience? Improving the theory through insights on practice. *Agroecology and Sustainable Food Systems*, *46*(6), 877-901. doi:10.1080/21683565.2022.2076184.

Verschuur, J., Li, S., Wolski, P., & Otto, F. E. (2021). Climate change as a driver of food insecurity in the 2007 Lesotho-south Africa drought. *Scientific Reports, 11*(1). https://doi.org/10.1038/s41598-021-83375-x.

VOA. (2016, November 16). WFP: Up to 600,000 people short of food in Burundi. Retrieved from https://www.voanews.com/a/reu-wfp-up-to-600000-people-short-of-food-in-burundi/3598049.html.

Vogel, E. (2022, October 18). Farm floods will hit food supplies and drive up prices. Farmers need help to adapt as weather extremes worsen. *The Conversation*. https://theconversation.com/farm-floods-will-hit-food-supplies-and-drive-up-prices-farmers-need-help-to-adapt-as-weather-extremes-worsen-192731.

Wang, X., Liu, Z., & Chen, H. (2022). Investigating flood impact on crop production under a comprehensive and spatially explicit risk evaluation framework. *Agriculture, 12*(4), 484. https://doi.org/10.3390/agriculture12040484.

Wheeler, T. R., Craufurd, P. Q., Ellis, R. H., Porter, J. R., & Vara Prasad, P. (2000). Temperature variability and the yield of annual crops. *Agriculture, Ecosystems & Environment*, *82*(1-3), 159-167. doi:10.1016/s0167-8809(00)00224-3

World Bank. (2022, October 17). *Putting Africans at the heart of food security and climate resilience*. https://www.worldbank.org/en/news/immersive-story/2022/10/17/putting-africans-at-the-heart-of-food-security-and-climate-resilience.

World Bank. (2023, August 28). *What is food security? There are four dimensions*. https://www.worldbank.org/en/topic/agriculture/brief/food-security-update/what-is-food-security#:~

World Bank. (2023, July 26). *Mali: Strengthening financial resilience to recurrent droughts*. https://www.worldbank.org/en/country/mali/publication/economic-update-mali-2023-building-financial-resilience-in-response-to-recurrent-droughts#:~

World Food Programme. (2020). *World food programme strategic plan 2020-2023*. WFP.

Yamane, Taro. *Statistics: An Introductory Analysis*. 1967.

APPENDICES

APPENDIX 1: QUESTIONNAIRE

Dear Respondent

My name is Jean Bosco KABUHUNGU, a master's student at the National Defence University-Kenya undertaking a Master of Arts in National Security and Strategy. I am conducting research titled; **Climate Variability and Food Security in Gatumba Zone, Burundi**. I am humbly requesting for your assistance to complete this study by responding to the questions in this questionnaire. I wish to clarify that your participation is voluntary and the information you shall provide will be treated in confidence, and utilized for the purposes of completing this research only. Thank you for your cooperation.

SECTION A: THE DEMOGRAPHIC INFORMATION OF THE RESPONDENT

SEX: Male [ ] Female [ ]

AGE: 21-30 [ ] 31-40 [ ] 41-50 [ ] 51-60 [ ] 62 and above [ ]

MARITAL STATUS: Single [ ] Married [ ]

EDUCATION: None [ ] Primary [ ] Secondary [ ] College [ ] University [ ]

OCCUPATION: Farmer [ ] Government Officer [ ]

SECTION B: EFFECTS OF DROUGHT ON FARM PRODUCTIVITY IN GATUMBA ZONE

1. Do you believe that drought is a major problem in Gatumba zone that is affecting farm productivity?

Yes [ ] No [ ]

2. What is the frequency of drought spell? Please pick the most appropriate

Very Frequent [ ]
Frequent [ ]
Occasional [ ]
Rare [ ]
Very Rare [ ]

3. Which crops are the most affected by drought?

……
……

4. How does drought affect planned planting in Gatumba zone?

Farmers reduce the planned planting acres	[ ]
Farmers abandon planting altogether	[ ]
No change in farmers planting plans	[ ]

5. What are the effects of droughts on production? You can tick more than one

The level of production reduces	[ ]
The quality of harvested crops is low	[ ]
None of the above	[ ]

SECTION C: THE EXTENT THAT FLOODS AFFECTS AGRICULTURE IN GATUMBA ZONE.

6. Have you noticed an increase in the frequency of floods in Gatumba zone in recent years?

Yes [ ] No [ ]

7. What are the most common effects observed on the farms as a result of flood? You can tick more than one

Destruction of plants [ ]
Soil erosion [ ]
Water logging [ ]

8. Which crops are the most affected when floods occur?

……
…….

9. Do floods cause the displacement of farmers from their lands?

Yes [ ] No [ ]

10. Overall, to what extent has floods affected the availability of food in Gatumba Zone?

Very great extent	[ ]
Great extent	[ ]
Moderate	[ ]
Little Extent	[ ]
Not at all	[ ]

SECTION D: CLIMATE VARIABILITY COPING STRATEGIES PRACTICED BY FARMERS IN GATUMBA ZONE.

11. Do you believe that the environmental hazards of drought and floods have been a cause of food shortage in Gatumba zone?

Yes [ ] No [ ]

12. What are some of the adjustments made by farmers enhance resilience against climate variability? You can tick more than one.

Switching to irrigation [ ]
On-farm rain water harvesting schemes [ ]
Mixed-crop farming [ ]
Soil conservation practices [ ]
Planting early maturing crops [ ]
Selling agricultural land [ ]

Mention any other…….

13. What are the measures has the government implemented to enhance the resilience of farmers against droughts and floods?

……
……
……
……..

14. In your opinion, do you believe the government is doing enough to cushion farmers from the effects of drought and flooding?

Yes [ ] No [ ]

15. What assistance do you believe the farmers need to counter the effects of climate variability?

……
……
……
……

16. What are the factors do you believe limit farmers from adopting coping strategies to mitigate the effects of droughts and floods on their farms.?

……
……
……
……

APPENDIX 2 : INTERVIEW GUIDE

1. What has been the impact of droughts in on farming in Gatumba Zone?
2. How do farmers respond when drought occurs when they are planning for the planting season?
3. How would you describe the flooding issue in Gatumba Zone?
4. Explains how the floods have resulted in the displacement of farmers from their lands?
5. Are the people of Gatumba looking for alternative methods of earning a living and abandoning farming?
6. Considering the environment challenges affecting this community, how would you describe the state of food security?
7. What methods have you observed being used by the farmers to counter the challenges of drought and flooding?
8. Which measures has the government implemented to help counter the climatic hazards in Gatumba Zone
9. What do you think about the government solutions in terms of their effectiveness
10. What suggestions can you offer for the people and the government in countering the problems of drought and flooding and their effects on food production?
11. What are the factors do you believe limit farmers from adopting coping strategies to mitigate the effects of droughts and floods on their farms?