CLIMATE VARIABILITY AND HOUSEHOLD FOOD SECURITY IN MASISI, NORTH KIVU PROVINCE, DR CONGO

BY

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DECLARATION

I declare that this research thesis except where otherwise indicated or acknowledged is my original work.

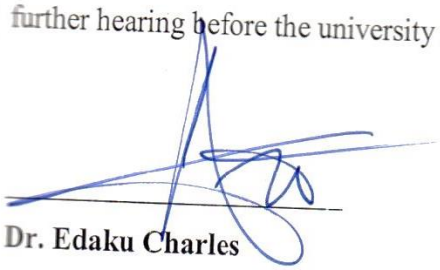
Mutabazi Harera Paul

8th /11 /2019

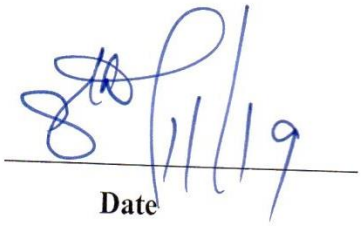
Date

APPROVAL

I declare that this thesis has been done by the student under my supervision and is ready for further hearing before the university research defense committee.



Dr. Edaku Charles



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DEDICATION

I dedicate this Thesis Report to my parents HARERIMANA NGABO and MUJAWIMANA JUDITH for their love, prayer and for their child brother Hon. NDAYISHIMIYE JUSTIN who supported me financially and emotionally and to ISRAEL and his wife SARAH who were always there for me when I needed assistance of any kind.

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My profound gratitude goes to the Almighty God for the gift of life and wisdom that He gave me throughout my studies.

My warm appreciation goes to my parents who supported me throughout my life most importantly academic life, May God reward them.

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I acknowledge with gratitude the contributions and co-operation made by the respondents from Masisi teritorry for their willingness to provide the necessary information when I visited them during the research process. Without their cooperation, this study would have been impossible to accomplish.

Finally my great appreciation goes to my friends, for their unconditional support. It is through them that I successfully completed this piece of work.

LIST OF ACRONYMS

ADRA	Adventist Development and Relief Agency
BXW	Banana Xanthomonas Wilt
CVI	Content Validity Index
DRC	Democratic Republic of Congo
FAO	Food and Agricultural Organization
FEWS NET	Famine Early Warning Systems Network
GDP	Gross Domestic Product
GIS	Geographic Information System
IPC	Integrated Food Security Phase Classification
IPCC	Intergovernmental Panel on Climate Change
KIU	Kampala International University
MRA	Mechanized Rain-fed Agriculture
NDVI	Normalized Differential Vegetation Index
SPSS	Statistical Package for the Social Sciences
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States AID
WASH	Water, Sanitation and Hygiene
WFP	World Food Programme

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study assessed the influence of climate variability on household food security in Masisi, North Kivu Province, DR.Congo. The following objectives guided the study: i) to assess the impact of climate variability on the food availability of the households in Masisi, DRC; ii) to evaluate the impact of climate variability on food accessibility of the households in Masisi, DRC; and iii) to assess the impact of climate variability on food utilization of the households in Masisi, DRC; and This study used a cross-sectional survey design. The target population was 300 participants and the sample size was 171 respondents who included community members and local village councilors. The study used simple random and purposive sampling to select the participants. Questionnaire, interview guide and document review were the instruments of the study. Data was analysed using frequency, percentages, mean, and linear regression analysis. The study revealed that climate variability significantly impacts on food availability at Masisi teritorry (Adjusted R Square=0.467, p=0.00). In addition, the study revealed that climate variability significantly impacts on food accessibility at Masisi teritorry (Adjusted R Square=0.366, p=0.00). Similarly, the study revealed that climate variability significantly impacts on food utilization at Masisi teritorry (Adjusted R Square=0.475, p=0.00). Lastly, the study revealed that the adaptation strategies employed by the households against climate variability include among others: receiving an education about climate variability, adopting early planting, diversifying crop and animal production, adopting the use of water harvesting and storage techniques, and planting weed tolerant crop varieties. The study concluded that climate change significantly affect food security. The study made the following recommendations: the local communities and households should adopt adaptation strategies such as promoting home gardens and small animal husbandry, improving food preservation and home or community processing technologies such as community silos; farmers should adopt the use of modified crops that have the capacity to resist natural occurrences and sudden climatic shocks curbing the pressure on the environment and in turn increasing the production of food without getting affected by climate; and the local government of Masisi teritorry with the support of the central government and donor communities should build permanent roads and bridges that are strong enough to withstand flooding during rainy seasons and dust during drought seasons.

CHAPTER ONE
INTRODUCTION

1.0 Introduction

This chapter covered the background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, scope of the study, significance of the study, definitions of key terms.

1.1 Background of the Study

This section covered the historical perspective, theoretical perspective, conceptual perspective, and contextual perspective.

1.1.1 Historical Perspective

An age-old phenomenon, climate variability can happen due to increasing population levels, innovation, high living standards, technological progress, industrialization, increasing infrastructure, reduction of trees and agricultural land. According to the results of Intergovernmental Panel on Climate Change (IPCC) (2014), the level of Greenhouse Gases has surpassed the highest levels of concentrations on earth over the last 800,000 years. This greenhouse effect, in turn, is causing increased rainfall, frequent hot extremes, floods, droughts, cyclones and gradual recession of glaciers. Rise in precipitation levels has been observed in Northern Europe, eastern parts of North America, South America, Northern Asia as well as Central Asia. Tropics and Sub tropics have been facing severe and long lasting droughts since 1970s whereas areas like Sahel, Southern Africa and Central Asia have parched lands (Kaur, 2017). According to the IPCC (2014) Fourth Assessment Report, intensification of activities performed by humans since 1750 has resulted in atmospheric concentrations of Carbon-dioxide, Methane and Nitrous Oxide around the world. The level of greenhouse gases has now exceeded the preindustrial values that existed thousands of years ago (Reddy, 2016).

Climate variability may not always have a negative effect on agriculture, especially in case of high latitude and high-income countries where agriculture cultivation is complimented by advanced technological implements and resources, leading to higher productivity of land (Narayanan, 2015). However, this climate variability is a major barrier to developing economies, like India, Pakistan, Bangladesh, Nepal, Sri Lanka, and Myanmar where agriculture accounts for more than 55 per cent of their total working population and constitutes averagely 14.1 per cent of

their GDP (Birthal et al., 2014). Furthermore, due to this alteration in climate, crop productivity is being affected adversely resulting in food and livelihood security issues (Tripathi, 2014). This climate variability coupled with the increasing poverty and unavailability of food has led to the immensity of food security challenges which further poses a threat to these nations, in their entirety.

Sub-Saharan Africa is already a continent under pressure from climate stresses and is highly vulnerable to the impacts of climate variability (Sulfab et al., 2015). Many areas in Sub-Saharan Africa are recognized as having climates that are among the most variable in the world on seasonal and decadal time scales (Yagoub et al., 2017). Floods and droughts can occur in the same area within months of each other. These events have also led to famine and widespread disruption of socio-economic well-being. For example, Obwocha (2015) indicate that one third of Sub-Saharan African people already live in drought- prone areas and 220 million are exposed to drought each year. Indeed, climate variability has drastically reduced agricultural production through extreme weather events, such as recurrent droughts and floods in several parts of Sub-Saharan Africa. For example, in Kenya and Uganda, frequent droughts and floods have not only claimed lives but have also decimated livestock and reduced farm output. In Kenya, for instance, West Pokot County is one of the food deficient and food insecure Counties in the Country (Huho & Mugalavai, 2018). On the other hand, in Uganda, the Karamoja, Northern and Teso sub regions have often times been hit by recurrent drought while the Elgon regions of Bududa and Rwenzori regions of Kasese have been hit by frequent floods and landslides claiming human lives and destruction of crops, animals and property (Nakileza, 2018). Due to unprecedented climate variability, most families have been displaced and have remained vulnerable and susceptible to food insecurity with majority unable to access or afford food.

In the Democratic Republic of Congo, it is projected that the country will experience an increase of 2 - 3 degrees Celsius by 2050 with an increase in extreme weather with intense precipitation and an increase in flooding (USAID, 2018). These climate projections will have impacts on agriculture and livelihoods, and water, sanitation and hygiene (WASH) and health. Regions of the DRC are already characterized by significant social vulnerability, including food insecurity, high levels of poverty and undernourishment. Dependence on rainfed agriculture dominates and current climate variability already negatively impacts crop productivity through floods, erosion

and heavy rains. Increased temperatures and more intense rainfall events alter the distribution and ranges of insect pests, weeds and pathogens and damage already limited transport networks. Climate projections suggest these extreme events will become more common in the target regions. Investments in these areas will therefore need to be adapted to these changing conditions to reduce the risks posed by climate variability and change (USAID, 2018).

According USAID (2018), the Famine Early Warning Systems Network (FEWS NET) projects revealed that many populations in other areas of southeastern DRC, as well as some areas in Ituri, North Kivu and South Kivu, is likely to experience Stressed (Integrated Food Security Phase Classification (IPC 2)) level of acute food insecurity during January 2019, as families deplete their food stocks and turn to coping strategies—such as decreasing the number of meals per day or buying less expensive food—to meet their food needs (USAID, 2018).

1.1.2 Theoretical Perspective

This study was guided by the Market-Based Approach and Institutional Failure theories by Sen (1983), Sen (2000), and Rolandsen (2019), and Anthropogenic Global Warming (AGW) theory by Al Gore (2006). The market-based approach is based on the idea that famine is not due to food supply but due to food access. The concept of entitlements developed by Sen (1983) partly joined this approach. The author suggests that people have an entitlement to food. Entitlement is defined as "the set of all possible combinations of goods and services that a person can obtain using the totality of rights and opportunities". Entitlements depend mainly on two factors: personal endowments and exchange conditions. The *endowments* are the combination of all resources legally owned by people, which include both tangible assets (such as land, equipment, animals, etc.) and intangible assets such as knowledge and skill, labour power, membership of a particular community, etc. In developing countries, an important part of a household's resources comes from labour activities. In other words, people's endowments are based on the revenues of employment and the possible earnings by selling non-labour assets. *Exchange conditions* allow people to use their resources to access the set of commodities through trade and production and the determination of relative prices of products or goods. Sen (1983) concludes later that an unfavourable shift in exchange conditions can be the factors of food insecurity.

Institutional Failures

This study was also guided by the theory of Institutional Failures by Rolandsen (2019) and Sen (2000). The authors have highlighted the importance of institutions as an explanation of food insecurity. According to Rolandsen (2019) and Sen (2000), the failure to deliver food can be due to the implementation of inappropriate policies or government's failure to intervene and the existence of civil conflicts. Sen (2000) suggests that democracy and political rights can help to prevent famines and other economic disasters. Indeed, authoritarian rulers tend to lack incentives to take timely preventive measures. In contrast, democratic governments have to win elections and face public criticism, and have strong incentives to undertake measures to avert food insecurity and other catastrophes. For example, democracy may provide some empowerment through voting by the poor to receive human resource investments in health, education and food transfers from government for broad-based development. In the absence of elections, of opposition parties and of scope for uncensored public criticism, authoritarian governments do not have to suffer the political consequences of their failure to prevent food insecurity.

Anthropogenic Global Warming theory

This study used the Anthropogenic Global Warming (AGW) theory by Al Gore (2006). This theory of climate change contends that human emissions of greenhouse gases, principally carbon dioxide (CO2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism whereby this happens is called the enhanced greenhouse effect. Energy from the sun travels through space and reaches Earth. Earth's atmosphere is mostly transparent to the incoming sunlight, allowing it to reach the planet's surface where some of it is absorbed and some is reflected back as heat out into the atmosphere. Certain gases in the atmosphere, called "greenhouse gases," absorb the outgoing reflected or internal thermal radiation, resulting in Earth's atmosphere becoming warmer than it otherwise might be.

1.1.3 Conceptual Perspective

Climate variability is the fluctuation of the climatic parameters of a region from its long term mean (Molu, 2016). Climatic variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (Badolo & Somlanaré, 2015). Variability may be due to natural internal processes within the climate system (internal variability), or to

variations in natural or anthropogenic external forcing (external variability). In this study, climate variability is operationalized using rainfall variability, and temperature variability.

Food security is a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Food and Agricultural Organization of the United Nations (FAO), 2010). Food security is a measure of the availability of food and individuals' accessibility to it, where accessibility includes affordability (Lobell et al., 2014). According to UNDP (1994), food security is a situation that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". This requires not just enough food to go around but necessitates that people have ready access to food, that they have an "entitlement" to food by growing it for themselves, by buying it or by taking advantage of a public food distribution system.

Tweeten (1997) emphasizes that the concept of food security has three essential dimensions. The first dimension is food availability, which refers to the supply of foodstuffs in a country from production or imports. The second dimension is food access, which refers to the ability to acquire food for consumption through purchase, production or public assistance. Indeed, food may be available but not necessarily accessible. Contrary to availability that reflects the supply-side, food access focuses on the demand side (Barrett, 2010). It takes into account the loss of livelihood producing assets, the incomes of households, the prices of goods and the preferences of households. The third dimension is food utilization, which concerns the physical use of food derived from human distribution. Food may be available to individuals who have access, but health problems may result from the imbalanced diet of food that is consumed. In this study, food security was operationalized as availability, accessibility and utilization.

1.1.4 Contextual Perspective

Nearly half of households in Masisi territory were moderately or severely food insecure according to analysis by the World Food Programme (WFP, 2017). A baseline survey by Keita (2017) revealed that 51% of children under 5 years were stunted. The study further found that major constraints to improving household production and marketing included: lack of access to

arable land; large pre- and post-harvest losses; crop disease; inability to access credit; long distances to market centers; and taxation (informal and formal) on products going to markets (Keita, 2017). According to a study by Slegh et al., (2018), within health and nutrition, households exhibited: poor dietary diversity and hygiene and sanitation practices; lack of water and sanitation infrastructure; poor understanding of optimal nutrition actions; and underutilization of deworming medicines and iron and vitamin A supplementation.

However, it should be known that agriculture is a central engine of DRC's economy and the primary source of livelihood for most Congolese, accounting for 40 percent of the national gross domestic product (GDP) and employing 70 percent of the country's population (Downie, 2018). With only about 10 million of approximately 80 million hectares of arable land under cultivation (mostly in the plateaus of Katanga region), DRC has the potential to become Africa's breadbasket. Promoting agricultural development is the cornerstone of the country's national economic development plan. However, climate variability and change is impacting this goal, as DRC's agricultural activities (which combine farming, hunting/gathering/fishing and small animal husbandry) are mainly rainfed and subsistence in nature (USAID, 2015).

In Masisi teritorry for instance, increased rainfall intensity is damaging crops and eroding fertile soil, which is leading to an intensification of crop diseases. In addition, prolonged dry spells and rising temperatures is stressing plants and reducing yields, thus putting pressure on farmers to expand their cropland into forests. Furthermore, climate variability in Masisi has caused the displacement of key activity seasons, impacting productivity and altering farmers' crop selection and production and processing practices. All these have been exacerbated by climate variability where most small scale farmers in Masisi teritorry are unable to farm their land and get productive food due to frequent floods, landslides, and pro-long droughts (USAID, 2018).

1.2 Statement of the Problem

Food security has deteriorated remarkably in the last twenty years in Masisi teritorry (WFP 2017). Masisi territory now has the highest level of food insecurity in DRC, with 64% considered food insecure (Oxfam 2018). Due to climate variability, there has been increased temperature variability with prolonged droughts and rainfall variability resulting in frequent experiences of floods in several regions of Masisi teritorry (Oxfam 2018). Farmers also report a significant drop in rainfall and erratic weather patterns compared to the past (Adventist

Development and Relief Agency (ADRA), 2018). This has subsequently reduced food security in Masisi. This study therefore assessed the effect of climate variability on the food security of the people of Masisi, DR. Congo.

1.3 Purpose of the Study

To assess the influence of climate variability on household food security in Masisi, North Kivu Province, DR. Congo.

1.4 Objectives of the Study

i. To assess the impact of climate variability on the household food availability in Masisi, DRC.
ii. To evaluate the impact of climate variability on household food accessibility in Masisi, DRC.
iii. To assess the impact of climate variability on household food utilization in Masisi, DRC.

1.5 Research Questions

i. What is the impact of climate variability on the household food availability in Masisi, DRC?
ii. What is the impact of climate variability on household food accessibility in Masisi, DRC?
iii. What is the impact of climate variability on household food utilization in Masisi, DRC?

1.6 Scope

1.6.1 Geographical Scope

This study was carried out in Masisi territory. Masisi is a district located within the North Kivu Province of the Democratic Republic of the Congo. Its geographical coordinates are 1° 23' 56" South, 28° 48' 48" East. Masisi Territory is administratively subdivided into four sectors: Bahunde, Bashali, Katoyi, and Osso.

1.6.2 Content Scope

This study was confined to climate variability as the independent variable and was measured using rainfall variability and temperature variability. Food security was the dependent variable and was measured using food availability, food accessibility, and food utilization.

1.6.3 Time Scope

This study took a period of 1 year, that is, from April, 2018 to April, 2019. This period was helpful in proposal writing, data collection, data analysis, and final report writing.

1.7 Significance of the Study

The results of this study will help agricultural planners in the Ministry of Agriculture of DR Congo in their planning activities and providing useful weather data that will guide in planning public (or planned) adaptations to complement the farm-level (or autonomous) adaptation strategies.

Furthermore, the results of this study are expected to give direction for policy makers in designing appropriate public policies to increase agricultural productivity and mitigating effects of climate change on food crop production in DR Congo.

In addition, it will provide a useful guide to international and local donor agencies interested in climate change mitigation and adaptation in their provision of grants and funds for environmental and resource management studies.

Additionally, researchers are going to have a good resource base to look at climate change for further work. Farmers are also going to benefit by knowing those adaptation strategies to climate change that are more productive and efficiency-enhancing.

1.8 Operational definitions of key terms

Climate variability: refers to the climatic parameter of a region varying from its long-term mean in terms of rainfall and temperature variability.

Food security: refers to the state of having reliable access to a sufficient quantity of affordable, nutritious food.

Food Availability: refers to when all people have sufficient quantities of food available on a consistent basis.

Food Accessibility: refers to the access by individuals to adequate resources for acquiring appropriate foods for a nutritious diet.

Food Utilization: refers to the ability of the human body to ingest and metabolize food through adequate diet, clean water, good sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This chapter reviewed literature from different authors and scholars regarding the study constructs and objectives. The chapter was subdivided into theoretical review, conceptual review, empirical studies, and gaps from the literature.

2.1 Theoretical Review

The Market-Based Approach

The market-based approach is based on the idea that famine is not due to food supply but due to food access. The concept of entitlements developed by Sen (1983) partly joined this approach. The author suggests that people have an entitlement to food. Entitlement is defined as "the set of all possible combinations of goods and services that a person can obtain using the totality of rights and opportunities". Entitlements depend mainly on two factors: personal endowments and exchange conditions. The *endowments* are the combination of all resources legally owned by people, which include both tangible assets (such as land, equipment, animals, etc.) and intangible assets such as knowledge and skill, labour power, membership of a particular community, etc. In developing countries, an important part of a household's resources comes from labour activities. In other words, people's endowments are based on the revenues of employment and the possible earnings by selling non-labour assets. *Exchange conditions* allow people to use their resources to access the set of commodities through trade and production and the determination of relative prices of products or goods. Sen (1983) concludes later that an unfavourable shift in exchange conditions can be the factors of food insecurity. Otherwise, a general shortfall of employment in the economy reduces people's ability to acquire an adequate amount of food. In other words, a change in relative prices of products or wage rate vis-à-vis food price can cause food insecurity.

In the market-based approach of food security, we also find studies on the relationship between economic performance and food insecurity. A poor economic performance can be a major cause of poverty. A person is considered to be in absolute poverty when s/he is unable to satisfy adequately his/her basic needs such as food, health, water, shelter, primary education and

community participation (Frankenberger 1996). The effects of poverty on hunger and undernutrition are pervasive. Poor households and individuals have inadequate resources for care and are unable to achieve food security and to utilize resources for health on a sustainable basis. In contrast, a sustained economic growth has a positive direct impact on food security by supporting agricultural production and hence food supply.

Wiesmann (2006) suggests that national incomes are central to food security and nutrition because food security, knowledge and caring capacity as well as health environments require a range of goods and services to be produced by the national economy or to be purchased on international markets. Using the Global Hunger Index (GHI) as measure of food security and Gross National Income (GNI) per capita, the author shows that the availability of economic resources at the national level largely determines the extent of hunger and undernutrition. Poor countries tend to have high GHI values.

Smith and Haddad (2000) believe that national income may enhance countries' health environments and services as well as women's education by increasing government budgets. It may also boost national food availability by improving the resources available for purchasing food on international markets. The authors emphasize that national income reflects the contribution of food production to overall income generated by households for countries with large agricultural sectors. Smith and Haddad (2000) also suggest that national income may improve women's relative status directly by freeing up resources for improving women's lives as well as men's. They conclude that there is a strong negative relationship between national income and poverty, as shown by recent studies (Easterly 2005; Ravallion 2008). These studies show that economic growth is a necessary condition for poverty reduction. By promoting poverty reduction, economic growth may reduce the constraints on food access for households and is therefore a source of food security.

Institutional Failures

This study was also guided by the theory of Institutional Failures by Rolandsen (2019) and Sen (2000). The authors have highlighted the importance of institutions as an explanation of food insecurity. According to Rolandsen (2019) and Sen (2000), the failure to deliver food can be due to the implementation of inappropriate policies or government's failure to intervene and the existence of civil conflicts.

Sen (2000) suggests that democracy and political rights can help to prevent famines and other economic disasters. Indeed, authoritarian rulers tend to lack incentives to take timely preventive measures. In contrast, democratic governments have to win elections and face public criticism, and have strong incentives to undertake measures to avert food insecurity and other catastrophes. For example, democracy may provide some empowerment through voting by the poor to receive human resource investments in health, education and food transfers from government for broad-based development. In the absence of elections, of opposition parties and of scope for uncensored public criticism, authoritarian governments do not have to suffer the political consequences of their failure to prevent food insecurity.

However, democracy would spread the penalty of food insecurity to the ruling groups and political leaders. This gives them the political incentive to try to prevent any threatening food insecurity. Sen (2000) also thinks that a free press and the practice of democracy contribute greatly to bringing out information that can have an enormous impact on policies for food insecurity prevention (for example, information about the nature and impact of new production techniques on food supply). The author concludes that a free press and an active political opposition constitute the best early-warning system for a country threatened by famines.

Smith and Haddad (2000) consider that democracy is hypothesized to play a major role in the reduction of food insecurity. According to these authors, a more democratic government affects large revenues in education, health services and income redistribution. This contributes to reduce the problems of food insecurity in the areas affected. Smith and Haddad (2000) also suggest that a more democratic government may be more likely to respond to the needs of all of its citizens, women's as well as men's. With respect to food security, the analyses of Dreze and Sen (1991), among others, conclude that democracy is very important in averting food insecurity. More democratic governments may be more likely to honour human rights including the rights to food and nutrition (Haddad & Oshaug 1998) and to encourage community participation, both of which may be important means for reducing child malnutrition (Isham et al., 1995).

Otherwise, other studies (Barnett, 2003) have established a relationship between civil conflicts and hunger in developing countries. Indeed, in the countries in conflict, population, households and individuals suffer disruptions in livelihoods, assets, nutrition and health. The Combatants frequently use hunger as a weapon by cutting off food supplies and productive capacities,

starving opposing populations into submission, and hijacking food aid intended for civilians. Warfare disrupts markets and destroys crops, livestock, roads and land. Deliberate asset-stripping of households in the conflict regions may cause those households to lose other sources of livelihood as the ongoing conflict leads to breakdowns in production, trade and the social networks. The disruption of markets, schools and infrastructure removes additional resources required for food production, distribution, safety and household livelihoods. These consequences aggravate food insecurity in the countries in conflict, like North Kivu, DRC.

Messer et al. (1998) have estimated the extent of food production losses due to conflict by examining trends in war-torn countries of Sub-Saharan Africa during 1970 to 1994 and found that food production was lower in the war years by a mean of 12.3%. This decrease in food production has significant impacts on food availability because in these countries, a majority of the workforce earned their livelihood from agriculture. In addition, in eight of the countries, two-thirds or more of the workforce were engaged in agricultural activities (World Bank, 1992).

Anthropogenic Global Warming theory

This study used the Anthropogenic Global Warming (AGW) theory by Al Gore (2006). This theory of climate change contends that human emissions of greenhouse gases, principally carbon dioxide (CO2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism whereby this happens is called the enhanced greenhouse effect. Energy from the sun travels through space and reaches Earth. Earth's atmosphere is mostly transparent to the incoming sunlight, allowing it to reach the planet's surface where some of it is absorbed and some is reflected back as heat out into the atmosphere. Certain gases in the atmosphere, called "greenhouse gases," absorb the outgoing reflected or internal thermal radiation, resulting in Earth's atmosphere becoming warmer than it otherwise might be.

Water vapor is the major greenhouse gas, responsible for about 36 to 90 percent of the greenhouse effect, followed by CO_2 (<1 to 26 percent), methane (4 to 9 percent), and ozone (3 to 7 percent). (These estimates are the subject of much dispute, hence their wide ranges.) During the past century, human activities such as burning wood and fossil fuels and cutting down or burning forests are thought to have increased the concentration of CO_2 in the atmosphere by approximately 50 percent. Continued burning of fossil fuels and deforestation could double the

amount of CO_2 in the atmosphere during the next 100 years, assuming natural "sinks" do not grow in pace with emissions (Intergovernmental Panel on Climate Change, 2007).

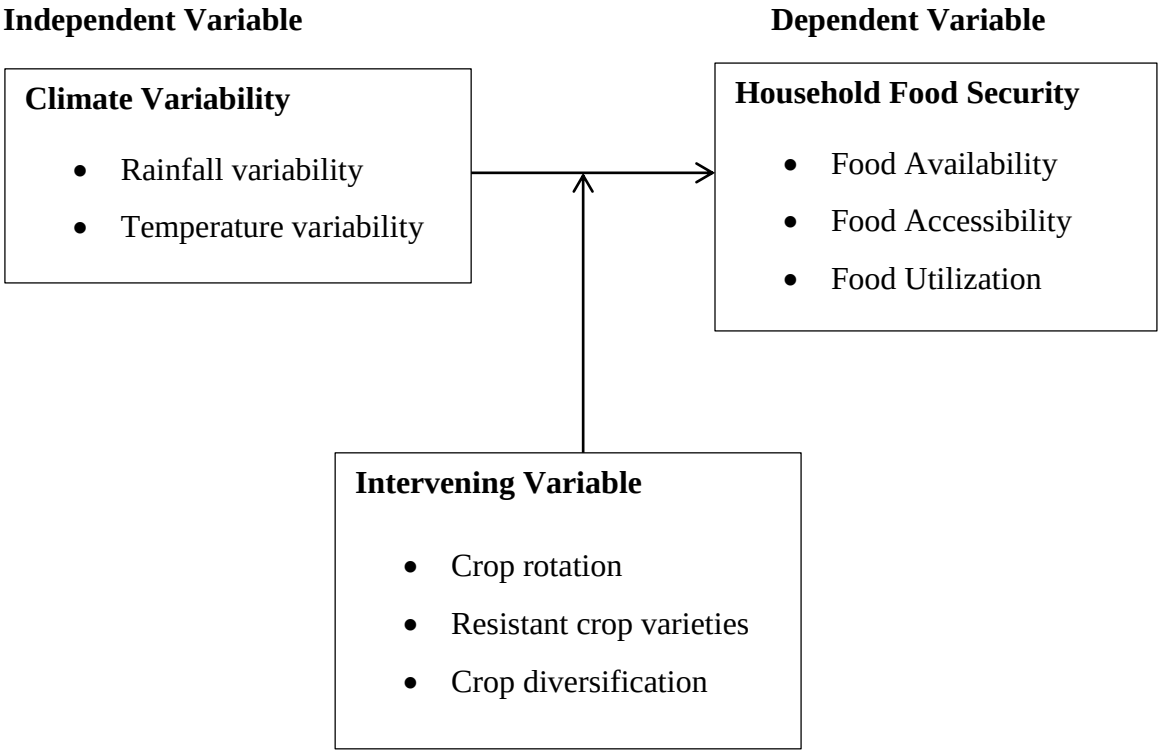
Earth's climate also responds to several other types of external influences, such as variation in solar radiation and in the planet's orbit, but these "forcings," according to the proponents of AGW, cannot explain the rise in Earth's temperature over the past three decades. The forcing caused directly by man-made greenhouse gases is also small, but the AGW theory posits that positive feedbacks increase the effects of these gases between two- and four-fold. A small increase in temperature causes more evaporation, which places more water vapor in the atmosphere, which causes more warming. Global warming may also lead to less ice and snow cover, which would lead to more exposed ground and open water, which on average are less reflective than snow and ice and thus absorb more solar radiation, which would cause more warming. Warming also might trigger the release of methane from frozen peat bogs and CO_2 from the oceans.

Backers of the AGW theory contend the ~0.7°C warming of the past century-and-a-half and ~0.5°C of the past 30 years is mostly or entirely attributable to man-made greenhouse gases. They dispute or disregard claims that some or perhaps all of that rise could be Earth's continuing recovery from the Little Ice Age (1400-1800). They use computer models based on physical principles, theories, and assumptions to predict that a doubling of CO2 in the atmosphere would cause Earth's temperature to rise an additional 3.0°C (5.4°F) by 2100.

When these climate models are run "backwards" they tend to predict more warming than has actually occurred, but this, the theory's backers argue, is due to the cooling effects of aerosols and soot, which are also products of fossil fuel combustion. The models also predict more warming of a layer of the atmosphere (the troposphere) in the tropics than has been observed by satellite and radiosonde measurements, but AGW believers dispute the data showing that disparity (Al Gore, 2006). Proponents of the AGW theory believe man-made CO_2 is responsible for floods, droughts, severe weather, crop failures, species extinctions, spread of diseases, ocean coral bleaching, famines, and literally hundreds of other catastrophes. All these disasters will become more frequent and more severe as temperatures continue to rise, they say. Nothing less

than large and rapid reductions in human emissions will save the planet from these catastrophic events .

2.2 Conceptual Review



Source: IPCC (2007); FAO (2010)

Figure 2.1: Conceptual Framework for Climate Change and Food Security in Masisi, DRC.

The above figure shows that the independent variable is climate variability measured using temperature variability, rainfall variability and adaptation strategies while food security is the dependent variable measured using food availability, food accessibility and food utilization. The effect of the independent variable on food security is that in case of drought, most crops and animals will die hence causing lack of food availability. Similarly, due to floods, most crops may end up being washed away by flooded waters, or the crops can end up rotting in the gardens for lack of enough sunshine hence causing lack of food availability and accessibility. However, proper climate variability adaptation strategies can bring about food availability, accessibility, and utilization.

2.3 Review of Related Literature

2.3.1 The impact of climate variability on food availability

In Sub-Sahara Africa, rainfall pattern is mainly influenced by El-Niño Southern Oscillation (ENSO) events. These often result into frequent extreme weather events such as droughts and floods which lead to reduced food production causing severe food shortages (Adusei-Gyamfi et al., 2019; Cooper et al., 2019). According to observations, ENSO influences contrasting rainfall variability in Sahel, East Africa and South East Africa with Sahel becoming drier, East Africa being wetter and South East Africa being stable (Saidia et al., 2019). Though the IPCC AR4 suggested potential increases in mean precipitation across East Africa, especially in summer, some recent work has contradicted this, suggesting the potential for decreased rainfall over Kenya in the future. Recent analysis has shown increasing drought and the country is exposed to a high water security threat. However, large uncertainties remain, and as such, knowledge is little improved beyond that reported in the Intergovernmental Panel on Climate Change Assessment Report 4 (IPCC, 2007).

Due to the widespread geographical distribution of river valleys and low-lying coastal areas, combined with their attraction for human settlement, flooding is the most frequent and economically disruptive of all environmental disasters in the world (Bazerman, 2016). Flooding can directly cause death or injury as well as indirectly cause a variety of delayed and long-term health impacts. This usually manifests itself through individual and community displacement, exposing individuals to a range of indirect stressors, such as social disruption, loss of possession, disrupted livelihoods and family life (Bostrom et al., 2018). These conditions also lead to ill-health effects through: unsafe sanitary environments, inadequate nutrition, and increased exposure to infectious diseases. Therefore floods are considered significant hazards because of their cumulative impacts on both individuals and communities (Hutton, 2017).

Flooding is primarily caused by hydro-meteorological conditions, including excess snowmelt, rain, snow, ice-jams, or natural dams (Andrews, 2016). Anthropogenic causes can also lead to flooding, or exacerbate natural flooding conditions, through changes in drainage patterns or dam-breaks (Pietroniro et al., 2016). Structural measures such as dams, dykes and diversions have been utilized in the most parts of Africa as a means of mitigating flood risk; however these measures have also disrupted riparian habitat and sometimes given the public a false sense of

security. Non-structural approaches, such as floodplain regulation and forecasting, have become increasingly favorable ways of mitigating flood risk and reducing damage (Pietroniro et al., 2016). Therefore flood prevention strategies should reflect the vulnerability/resilience paradigm which stresses that societal dimensions are equally or more important in coping with disasters like floods, than solely trying to control nature with technology (Haque & Etkin, 2017).

2.3.2 The impact of climate variability on food accessibility

The continent of Africa is generally noted to be hot and dry with current trends showing warmer spells than it was 100 years ago (Hulme, 2005; Issahaku & Abdulai 2019; Saidia et al., 2019). Warning trend has been noted likewise since 1960s. The 21st century has been warming at about 0.5oC/century (Saidia et al., 2019). Reum et al., 2019 in Saidia et al., (2019), recorded 1987 and 1998 as the warmest years. Sub-Saharan Africa (SSA) is anticipated to warm as it lies in tropical and subtropical latitudes, where temperatures are high throughout the year (Saidia et al., 2019). In future, the whole of Africa is expected to warm across all seasons throughout the century (Saidia et al., 2019). In SSA, by 2100, the temperature rise will be about 2-4.5^{o}C which is expected to be stronger than global average (Ali, 2018).

According to Molu (2016), high ambient temperature, relative humidity and radiant energy compromise the ability of animals to dissipate heat. As a result, there is an increase in body temperature, which in turn initiates compensatory and adaptive mechanisms to re-establish homeothermy and homeostasis. These re-adjustments, generally referred to as adaptation, may be favourable or unfavourable to economic interests of humans, but are essential for survival of the animal. For an already hot area though, the adjustment are largely unfavourable. Thus, an increase in air temperature would affect directly animal performance by affecting animal heat balance.

In many parts of SSA, natural disasters revolve around either too much rain (flooding) or too little rain (drought). Unpredictable rainfall and increased temperatures are projected to increase frequency and intensity of the extreme weather events. Droughts and floods have been commonly experienced in many parts of SSA especially around the Horn of Africa and the Sahel (Saidia et al., 2019). A third of population in Africa resides in drought prone areas and therefore is vulnerable to the impact of droughts (UNDP, 2008). It is indeed recorded that in the Sahel, the Horn of Africa and Southern Africa since 1960 drought is strongly persistent (UNDP, 2008).

Closer home, in 1990s and 2000s, a number of East African countries, including Ethiopia, Kenya and Somaliland, have suffered severe droughts. Food was scarce and rendered many people food insecure. According to UNDP's Human Development Report 2007/8, the 2000/2001 and 2006 droughts were the worst in the last 60 years in Kenya affecting more than 3.5 million people.

Historically throughout the 20th century, a rise in temperature has been correlated with increased drought (IPCC, 2007). Accordingly, temperature in the continental interior of Africa is predicted to sharply increase and therefore lead to an increase in the frequency, intensity, and scale of drought in the future (Wheaton et al., 2017). This is especially true in regions where climate circulation changes cause rainfall to decrease, however drought could become more frequent in regions that also see an increase in precipitation (IPCC, 2007). In a warmer climate, increased evaporation from soils and transpiration from plants may offset any additional increase seen in rainfall. Furthermore, an increase in extreme precipitation events means that most of the rainfall in a region will come in fewer days, resulting in more dry days. Heavy precipitation events are inefficient at recharging soil moisture, because they happen so quickly, and often result in surface runoff (Etkin & Ho, 2017).

Since most human activities and ecosystem health are dependent on reliable, adequate water supply, droughts present a serious national threat to DR. Congo (Bonsal et al., 2014). Large-scale droughts have major impacts on a wide range of water-sensitive sectors including agriculture, industry, municipalities, recreation, and aquatic ecosystems. They often stress water supplies by depleting soil moisture reserves, reducing stream flow, lowering lake and reservoir levels, and diminishing groundwater supplies (Hurd et al., 2015).

Droughts are described as a 'creeping' hazard because unlike most other natural hazards they develop slowly over time and can last for prolonged durations (Kempton, 2016). Droughts can be grouped into three main categories, including meteorological drought, hydrological drought and agricultural drought. Meteorological drought is defined as a deficit in precipitation, while hydrological drought is specific to a decline in the water table, effecting lakes, rivers and aquifers (Kharin & Zwiers, 2016). An agricultural drought, which is the focus of this research, is defined as a deficiency in water as to inhibit the production of agriculture (Leiserowitz, 2016). Agricultural drought occurs in the domain in which the hazard of drought and the human/social element come into direct contact. Agricultural drought results in the direct loss of income to

agriculturally based families and businesses and is therefore the most significant type of drought worth examining in regards to climate change (Khandekar, 2014).

The most direct impact of climate variability on food security is through changes in food production. Short term variations are likely to be influenced by extreme weather events that disrupt production cycles. These more geographically heterogeneous impacts are difficult to predict with accuracy and have a bearing on the stability aspect of food security. Most assessments of the impacts of climate change deal with aggregate changes (gains and losses) in arable land, changes in actual and potential yields, and inter-annual variability of harvests. Climate change is projected to lead to 5-170 million additional people being at risk of hunger by 2080 (Schmidhuber & Tubiello 2007), with this large range explained by the variations in different model outputs. Most of these food insecure people will be located in arid regions and the sub-humid tropics, particularly Africa, which is projected to suffer reductions in yields and decreases in production under both models.

In addition, the consensus of scientific opinion is that countries in the high temperate and mid-latitude regions are generally likely to enjoy increased agricultural production, whereas countries in tropical and subtropical regions are likely to suffer agricultural losses as a result of climate change in coming decades (Berhanu & Wolde, 2019). It should be noted that the favorable assessment for temperate and high latitude regions is based primarily on analyses of changes in mean temperature and rainfall; relatively little analysis done to date takes account of changes in variability and extremes. Impact of climate variability on crop production should be a priority given that analyses of agricultural vulnerability indicate that the key attributes of climate change are those related to climatic variability, including the frequency of non-normal conditions (Suri et al., 2019).

According to Sianungu (2015), access to food depends on the physical factors, as well as social and economic factors. After food is produced, it needs to be moved from the point of production to the point of consumption. This often depends on transport systems. In many developing countries, inefficient and ineffective transport systems retard the delivery and increase the price of food. Climate change is expected to place a strain on transport systems (IPCC, 2001). For example, increased rainfall, flooding and mud may cause several roads to be impassable (Perry and Symons, 1994). Moreover, rainfall variability contributes to underinvestment and hence to

long-run agricultural stagnation and rural poverty in countries that are dependent on rain-fed agriculture (Kydd et al. 2004). This leads to a decrease in food availability and accessibility.

2.3.3 The impact of climate variability on food utilization

Climate variability with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID 2004; Kinuthia, 1997). According to DFID (2004) climate change will result in Northern and Southern latitudes getting drier while the tropics are expected to become wetter. Moreover, climate variability is expected to increase the frequency and intensity of extreme weather conditions in Africa. The implications for southern Africa for example, are that the region would generally get drier and experience more extreme weather conditions, particularly droughts and floods, although there would be variations within the region with some countries experiencing wetter than average climate.

Climate variability is emerging as one of the main threats to sustainable food security in developing countries (Izaurralde, 2009). In particular, climate variability is expected to affect agricultural production due to increasing temperatures, changing precipitation patterns, and more frequent extreme weather events. It is estimated that the mean global temperature will rise by 1.8–4.0 °C by the end of the twenty-first century, which will reduce the yields from rain-fed agriculture in some regions by up to 50% by 2020 (IPCC, 2007). This is particularly relevant for Africa because livelihoods are based mainly on climate-dependent resources and environmental factors. The effects of climate change in Africa will thus be disproportionate and severe (Asfaw and Jones, 2010).

The IPCC´s fourth assessment report describes a trend of warming for Africa that is faster than the global average, showing that climate change is already a reality. Temperature in Africa has risen by 0.7°C during the 20th century and a 0.2 to 0.5°C temperature increase per decade is predicted while precipitation patterns vary considerably. Changes in frequency, intensity and predictability of rain are some of the most severe consequences of climate change for East Africa. According to the IPCC (2007) by 2020 crop yields depending on rain would decrease by up to 50 percent.

In Africa, low levels of food security and economic development conspire with high levels of climate risk (FAO, 2012). Warmer temperatures affect crops and crop production, and changes in rainfall patterns are as important. Climate change also influences the availability of water for human consumption and for food production (Vitali et al., 2019). Climate change represents an immediate and unprecedented threat to the food security of hundreds of millions of people who depend on small-scale agriculture for their livelihoods. In many African countries and regions, food security is likely to be severely compromised by climate change and climate variability. By the 2080s, climate change is estimated to place an additional 80–120 million people at risk of hunger, and 70–80% of these will be in Africa (Wang & Hijmans, 2019).

Adequate food utilization is realized when "food is properly used, proper food processing and storage techniques are employed, adequate knowledge of nutrition and child care techniques exists and is applied, and adequate health and sanitation services exist" (USAID, 1992). Food utility involves how food is used. This can include how often meals are eaten and of what they consist. Constraints to food utilization include loss of nutrients during food processing, inadequate sanitation, improper care and storage, and cultural practices that negatively impact consumption of nutritious foods for certain family members.

In many areas where food is produced and consumed locally, food utility changes with seasonal variation and food availability changes throughout the year (Izaurralde, 2009). The hungry season is the time before the planted crops are ready to be eaten. Similarly, at harvest time, there might be festivals and a lot of food consumed. If there has been a drought and food availability is low, the range of food available often decreases, and so the meal frequency can decrease and the balance of nutrients can be inadequate. This can lead to malnutrition in children. It is also important to note that climate can have an impact on food utility indirectly. For example, if there are hot dry days, crops and vegetables may be dried so that they can be used later in the year. At the same time as seasonal crop production, many households face fluctuations in cash and in-kind income, both within a single year and from year to year. Agricultural households may face seasonal fluctuations in income related to crop cycles. Year-to-year fluctuations in income can result from varying agro-climatic conditions and climate variability (Wang & Hijmans, 2019).

2.4 Climate Variability

Climate variability is often used to describe any kind of change in climate that may be natural or human-induced (Yucedag et al., 2018). Climate variability is caused by both human activities and natural occurrences (Hegerl et al., 2007; IPCC, 2007). The effects of climate variability come in the form of rising temperatures, unpredictable rainfall, loss of soil moisture, and increased evaporation and transpiration, among other effects (Ofori-Sarpong, 2011). Climate variability has had a significant impact on agriculture in many parts of the world (IPCC, 2007). Drastic changes in rainfall patterns coupled with rising temperatures result in unfavourable growing conditions and changes in the cropping calendar, thereby modifying growing seasons—which can subsequently reduce productivity (Manneh et al., 2010). Temperature and rainfall affect the development of plants, either alone or by interacting with other factors (IPCC, 2007). It has been estimated that even a small rise in temperature (1–2 ºC) at lower latitudes, especially in dry tropical regions, could decrease crop productivity (IPCC, 2007).

In general, temperature determines the length of the growing season of a crop by determining the crop's germination and vegetative and reproductive stages (FAO, 2009). Increased temperature leads to increased evapotranspiration and affects water availability, which is very important in the process of photosynthesis (Dawyer et al., 2006). In general, high temperature affects the chloroplasts where photosynthesis takes place through generation of reactive oxygen species (Sehgal et al., 2019). Water shortage and heat stress are two of the most important environmental factors limiting crop growth, development, and yield (Prasad & Staggenborg, 2008). Warming trends are responsible for the suppression of global agricultural productivity (FAO, 2009). Low temperatures also affect crops by reducing their metabolic reactions (Noyce et al., 2019).

Evidence of climate variability and change in Africa has been derived from instrumental climate, geological, remote sensing, and proxies of other climate sensitive parameters by various authors (IPCC, 2001). Climate modelling also provides complex tools that can be used to address various aspects of climate sensitivity. Details of these tools and methods are well documented by IPCC (2007). The results from the recent climate studies in Africa have shown among others that: increase in the mean temperature of the continent in recent years; increase in both maximum and minimum temperatures at many locations; rapid melting of the glaciers in the African glacial tropical mountains. The gradual dramatic disappearance of glaciers on Mount Kilimanjaro has

been associated with global warming (IPCC, 2007); an estimated 82% of the icecap that crowned the mountain when it was first thoroughly surveyed in 1912 is now gone and according to recent projections, if recession continues at the present rate, the majority of the glaciers on Mount Kilimanjaro could vanish in 15 years; declining/increasing trends of rainfall at some locations including the Sahel (Ogallo, 2009).

Apart from the long-term climate trends, there is substantial inter-annual variability in climate in Africa leading to droughts and floods with far reaching impacts. Recent observations show severe droughts being followed directly by severe floods or *vice versa* (Ogallo, 2009). Such climate extremes are linked to El Niño Southern Oscillation (ENSO) and dipole systems such as the Indian Ocean Dipole. Climate change leading to changes in the space-time patterns will bring new risk levels on society and livelihoods, water resources, ecosystems, and other natural resources that will threaten Africa's development and require new or modified adaptation strategies (Ogallo, 2009).

2.5 Food Security

Food insecurity happens to people when they do not have sufficient food to satisfy their hunger, they have bounded diet, are keen to have adequate food and shift to begging, snatching, hunting, becoming dependent on government programmes (Cook & Frank, 2018). Furthermore, Tripathi (2017) added that marginal disposable income, scarcity of resources and socio economic resources are factors contributing to the problem of food insecurity of a country. Many researchers found an interrelationship between food security and factors like water, agriculture growth, prices of food grains, energy and environment change (Basak et al., 2015; Blanco 2016). A large proportion of the population in developing countries is dependent on agricultural activities for livelihood. According to Bala and Hossain (2018), agriculture is the main source of income for 2.5 billion people, out of which 1.3 billion people are landless and marginal laborers. Approximately 86 percent of the poor rural population of the world is employed in the agriculture sector thus, making agriculture productivity important for the economic growth of a nation (Bala & Hossain 2018).

According to FAO (2010), there can be two main implications of changing agricultural patterns and productivity on food security in developing countries. Firstly, variations in the productivity

affect food security at a national as well as at a global level. Due to high dependency of the country on its own food production and its scarce financial and technological resources to import/export to other countries, it is difficult for the low income, developing countries to deal with a shortage in the supply of food grains. Secondly, there is a higher risk for the agricultural producers in rural areas to tackle any variations in the food supply as they are solely dependent on agriculture for their livelihood (Hoff, 2015).

Food security has been defined in multiple ways that can best be summarized in three dominant paradigms. The first paradigm understands food insecurity and famine as a direct consequence of food shortages caused by climatic variables (environmental view) or demographic pressures (neo-Malthusian or demographic theory) (Stevenson, 2012). Climatic variables attracted widespread attention during the droughts of the 1970s in the Horn of Africa, which caused large-scale famines. These famines were explained as the consequence of a lack of capacity of social systems to deal with external (climatic) shocks (Bruening et al., 2017). The dominant policy response was massive food aid. Neo-Malthusian theory comes to a similar policy recommendation in its call for increased agricultural production. According to this theory, food insecurity and famine are caused by food availability decline due to rising demand (demographic pressure) and stagnating production. Even if this view has lost much of its attraction, it is still pursued by leading think tanks such as the World watch Institute, which has warned of a "new era of food scarcity" (Arriola, 2015).

In the early 1980s, the theses of declining carrying capacities and supply failures were rejected by Amartya Sen, whose "entitlement theory" of famine made a distinction between the availability of food and people's ability to acquire it. This ability is reflected by people's "exchange entitlements" or livelihood sources, which include production-based entitlements, own-labour entitlements, trade based entitlements and inheritance and transfer entitlements. In this view, famines and other food related emergencies are economic disasters caused by failures of demand, or by a sharp decline in people's entitlements which leads to inability to command enough food for subsistence even when markets are well stocked (Bastos, 2008). In order to prevent famine, therefore, interventions should strengthen people's access to food either by the production of food or by the exchange of other commodities or services for food (Lemba, 2009). This economic view of food security, which is also repeated in the World Bank's definition of

food security ("access by all people at all times to sufficient food for an active, healthy life" (World Bank, 2001), disregards the notion of sustainability, or sufficient access to food over the long term, and the notion of vulnerability, or the risk of exposure to shocks and the ability to cope with these shocks and recover from risks to livelihoods.

Sen's stress on the relationship between people and markets as the root of famine also neglects the political context or the larger "structures of inequality" that explain why some people have easier access to food than others (Seddon & Adhikari, 2003). It also fails to explain why famine may create opportunities and benefits for some while reducing them for others. Since the 1990s, an increasing number of authors view famine as a political phenomenon that is not caused by lack of food production or market deregulations, but by political powerlessness. Keen has stressed that "a lack of lobbying power within national (and international) institutions" is the main reason for food insecurity (Rolandsen, 2019). It is the wider political and institutional context that explains why those hit hardest by famine are those that are the most politically vulnerable. De Waal goes even further and claims that "famine is caused by failures of political accountability" (de Waal, 1997). Rather than strengthening the availability of food and people's access to food, the political famine theory urges that interventions focus on state reconstruction, good governance and accountability.

The advantage of the last paradigm is that it offers a valuable framework to relate people's livelihood strategies to structures, institutions and organizations, or to the wider political economy. If food security in its most extreme appearance is "a socio-economic process which causes the accelerated destitution of the most vulnerable, marginal and least powerful groups in the community, to a point where they can no longer, as a group, maintain a sustainable livelihood", it is also the outcome of political structures and processes (Brunelin, 2014). A better understanding of the complex and open-ended phenomenon of food insecurity thus includes a comprehension of the key mechanisms that cause unequal food availability and unequal entitlements to food, as well as of people's coping strategies and the range of constraints and opportunities affecting the livelihood strategies of households and individuals.

2.5.1 Food Availability

Food availability is concerned with the production and supply of crops. Agriculture plays an indispensable role in the economic growth of a country. According to Kaur (2017), it not only

provides the nation with food, but is also responsible for generating employment, savings, supporting all the other sectors of the economy and earning foreign exchange for the country. Agriculture is a source of employment to 85% of the Democratic Republic of Congo. The food grain production in DR Congo has increased tremendously however, malnutrition and poverty levels continue to shoot up as a result of biotic, abiotic and sociopolitical situations (Ngigi, 2016).

The World Food Programme defines availability as the amount of food that is present in a country or area through all forms of domestic production, imports, food stocks and food aid (WFP, 2009). Riely et al., (1995), confirms that the term tends to be applied to food available at a regional or national level rather than at the household level, which can lead to some confusion as the word "availability" sometimes is used at the micro-level.

2.5.2 Food Accessibility

Food Accessibility refers to the physical access to food or affordability of the food. Intergovernmental Panel on Climate Change (IPCC) (2014) Fourth Assessment Report states that there will be approximately 200-600 million hunger stricken people around the world by 2080. In 1990-1991, the GDP at factor cost had increased at seven percent per annum, whereas it amplified at five percent per annum in 2013-2014, however, there has only been slight improvement in the amount of undernourished people from 210.1 million in 1990 to 194.6 million in 2014. According to De Salvo et al., (2013), food accessibility is not only a problem limited to the rural households but it also extends to the urban areas. Poor households from the rural areas migrate to the urban cities looking out for employment opportunities. Reddy (2016) argues that poverty and hunger drives the rural population to the urban slums. These people undertake menial jobs in order to meet the basic necessities and are exploited in terms of wages. Food is the main expenditure for urban poor and this section of the society is the worst hit by any increase in the food grain prices followed by production shocks due to change in the climate conditions.

The World Food Summit defines access as having "physical, economic and social access". Access is still not commonly accepted as an essential part of food security despite Amartya Sen's introduction of the concept in the early 1980s. Many people only consider access within an economic or financial context, particularly since the 2005 Niger food crisis and the start of food

price volatility in 2008. The World Food Programme defines food access as "A household's ability to acquire adequate amount of food regularly through a combination of purchases, barter, borrowings, food assistance or gifts (WFP, 2009).

Food access consists of three elements, which are physical, economic/financial and socio-cultural. The physical dimension can be illustrated by a situation where food is being produced in one part of a country but an inefficient or non-existent transport infrastructure means that food cannot be delivered to another part suffering from a lack of food. From the economic viewpoint, food security exists when people can afford to buy sufficient food. The idea that food insecurity arises when food is available but people are unable to afford it is still quite a recent development in the history of food security. A further economic consideration is the importance of market systems to ensure access to food as OXFAM points out: "Even in rural areas most people, and especially the poor, rely on market systems to provide food and essential goods and services but also for selling their produce (OXFAM, 2007).

The third element is the socio-cultural dimension which arises when food may be physically available and the potential consumer has the money to buy the food but is prevented from doing so for being a member of a particular social group or even gender. Social conflict and civil strife can seriously disrupt food production and lead to the loss of livestock for example with dire consequences for a household's future food security (Riely et al., 1999).

2.5.3 Food Utilization

Food utilization implies that food is properly used; proper food processing and storage techniques are employed; adequate knowledge of nutrition and child care techniques exists and is applied; and adequate health and sanitation services exist (Birthal et al., 2014). This focuses on the importance of non-food inputs. It takes into consideration the quality of food people eat and its nutritional value. It also encompasses the process of preparing the food, distribution, health-care, water supply and sanitation conditions. According to Narayanan (2015), this aspect can be measured with the help of immunization chart, health and demographic surveys.

On the other hand, the World Food Summit's (1996) definition of utilization (the third element of food security) is "safe and nutritious food which meets their dietary needs". The availability of and access to food on their own are not enough, people have to be assured of "safe and nutritious

food". The food consumed has to provide sufficient energy to enable the consumer to carry out routine physical activities. Utilization also covers factors such as safe drinking water and adequate sanitary facilities to avoid the spread of disease as well as awareness of food preparation and storage procedures. Utilization therefore covers a range of aspects that hinge on the consumer's understanding of what foods to select and how to prepare and store them. It is often a mistake to assume that the members of so-called traditional societies know how best to use food resources and it is also a fact that dietary habits (breast-feeding, weaning foods) change very quickly, even for traditional societies (Wiesmann, 2015).

2.5 Gaps of the Study

Several studies have been done on the subject of climate change and food. For example, Yagoub et al., (2017) conducted a study to investigate the impacts of climate variations on land use policies, food security and vegetation cover in Gadarif State (eastern Sudan) during 1961 to 2013. Furthermore, Otitoju (2013) examined the effects of climate change adaptation strategies on food crop production efficiency in Southwestern Nigeria, and Shisanya (2015) examined in specific terms the interaction between household food security and rural farming communities' perception of climate change in Mzinyathi District Municipality of KwaZulu-Natal, South Africa. The above studies however, did not measure food security in terms of food availability, food accessibility and food utilization, thus presenting content gap which this study investigated. Furthermore, none of the above studies was conducted in the Northern Province of DRC thus presenting a contextual gap that this study investigated. In addition, climatic change is a global phenomenon that is changing drastically every year, thus the time frame for the above studies are obsolete considering the rapid changes in climate. Thus there was a time gap that the above studies present since most of them were done in 1960s, 1980s, 2000s. It was therefore imperative that the present study be conducted to close such time gap.

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter covered the research design, study population, sample size, sampling techniques, data sources, research instruments, validity and reliability, data collection procedures, data analysis, ethical considerations, and limitations of the study.

3.1 Research Design

This study used a cross-sectional survey design. This is a type of observational study that analyzes data collected from a population, or a representative subset, at a specific point in time (Shields & Rangarajan, 2013). The data gathered was from a pool of participants with varied characteristics and demographics. The justification of the use of cross-sectional design was because the research findings helped to remove assumptions and replace them with actual data on the specific variables that will be studied during the time period accounted for in the cross-sectional study. The quantitative approach was used to ensure that generalizable numerical data are collected using questionnaires. On the other hand, the qualitative approach with the help of interviews was used to collect none-numerical data to provide interpretive evidence associated with quantitative findings. The study's preference for this design is attributed to its ability to provide generalization of the effect of climate change on food security in North Kivu, DRC.

3.2 Study Area

This study was conducted in Masisi town in the North Kivu Province of the DRC. It is the administrative center of Masisi territory. The coordinates of Masisi is $01^{0}24'00"S28^{0}49'05"E$. Masisi lies approximately 69 kilometres by road, northwest of the provincial capital of Goma. As of 2010, the population of Masisi is 6,502 people. The common languages spoken are Hunde, Hutu, Batembo, Tutsi, and Batwa. Masisi has diverse agro-ecological zones that can support growth of a wide array of crops suitable to more temperate zones compared to the rest of DRC. As a result, agriculture is the most important livelihood in this area, with 91% of the population engaged in this activity.

3.2 Study Population

The study population of Masisi is 6,502 people (DRC Demographic and Health Survey, 2018). However, this study targeted 300 family members (i.e. the local community/farmers, and local leaders, e.g. village local councilors) using simple random sampling technique. The participants were involved in the study because they are directly affected by the climate variability impacts and the understand very well the household food security of the communities they live in.

3.3 Sample Size

The sample size was determined using Slovene's formula;

$n = \frac{N}{1+N\,(\alpha)^2}$; Where n=sample size; N=target population; α=0.05 level of significance.

$$n = \frac{300}{1+300\,(0.05)^2}$$

$$\boldsymbol{n = 171}$$

Therefore, the sample size of this study was 171 respondents.

Table 3.1: Quantitative Sample Size

Category of Respondents	**Target Population**	**Sample Size**	**Sampling technique**
Local community	242	138	Simple random
Village councilors	58	33	Simple random
Total	**300**	**171**	

Source: DRC Demographic and Health Survey (2018)

Table 3.2: Qualitative Sample Size

Key Interview Informants	**Sample Size**	**Sampling technique**
Farmers	4	Purposive
District leaders	4	Purposive
Total	**8**	

3.4 Sampling Procedure

The study employed stratified sampling method to select 300 households in Masisi territory. The study used the following approach to select the households: the study divided Masisi into four equal strata, and the stratum with the most densely populated households was selected. Similarly, the researcher used simple random sampling to select the households in the selected stratum. Each household had equal chance of representation in the study. However, the researcher selected only households that had a wife, husband or family head who was more than 20 years of each. The study used simple random sampling to select the local community members/farmers and the local leaders. Simple random sampling was used because it provides equal opportunity for each person to participate without biasness.

On the other hand, the key informants were selected using purposive sampling. Saunders et al. (2012) observed that purposive sampling allows selection of a sample without bias to ensure inclusion of those respondents who are most suitable to provide useful information to the study. Further, the authors argue that it yields non-statistical findings which are not generalizable to the entire population and it targets only very knowledgeable people who understand the subject matter. Thus the study used purposive sampling to select key farmers and village leaders because they were judged as more informed of the research subject matter.

3.5 Data Source

This study used primary and secondary sources of data from questionnaires, interviews and document review respectively.

3.5.1 Primary Data

This study used questionnaire and interview guide as the main sources of primary data.

3.5.2 Secondary Data

This study used secondary data from document review such as journals, articles, metrological reports, World Food Program annual reports, FAO and government reports about climate change and food security.

3.6 Data Collection Method

Data was collected using survey, interview, and document review methods. The study preferred to use survey method because it is good for gathering descriptive data, relatively easy to administer, cost effective and time saving. This method was used to collect data from the local community and local leaders to get information about climate change and food security using questionnaires. Furthermore, interview method was used because it gives opportunity for clarifying questions. The researcher used interview guide to collect data from extensive farmers, and village leaders about climate change and food security using interviews.

3.7 Research Instruments

3.7.1 Questionnaire

This study used closed-ended questionnaires to collect data from the local community and local leaders about climate variability and food security. Questionnaires were preferred because they ensure the study reaches the big sample in the study. Secondly, it allows the gathering of valuable data only within the variables of interest in the study. Kothari (2009) observes that close-ended questions on a 5-point scale yields consistent and standardized data to allow quantitative analysis deemed appropriate to answer the study questions. Thus this study used a 5-Likert Scale where, 5=strongly agree, 4=agree, 3=not sure, 2=disagree, and 1=strongly disagree.

3.7.2 Interview Guides

Interview guide was distributed to the village leaders and extensive farmers. Drawing from Creswell (2014), interviews and more specifically the open ended questions in this study allowed probing to obtain a more comprehensive understanding of the problem climate variability and its nexus with food security. In view of Bryman and Bell (2011), qualitative data collection provides more room for interviewees to express their thoughts and interviewers to probe on the issues under investigation, which is vital to enhance validity of the findings. The study preferred to use interview tool because it enables the researcher to establish rapport with potential participants and therefore gain their cooperation, yields the highest response rates in survey research, and allows the researcher to clarify ambiguous answers and when appropriate, seek follow-up information (Bryman and Bell, 2011).

3.8 Validity and Reliability

3.8.1 Validity

To ensure quality, the questionnaire, was subjected to validity tests as recommended by Feldman (2007). Content validity was tested using a Content Validity Index (CVI). Content validity is the extent to which the items in the instrument represent the content of the attribute being measured. The researcher ensured this through judgment of the items by experts (namely: two research supervisors). The CVI was expressed as:

CVI= $\frac{n}{N}$

$$CVI = \frac{22}{24}$$

$$\boldsymbol{CVI = 0.92}$$

Where **n**=number of items rated relevant by all judges; **N**=total number of items in the instrument.

According to Amin (2005), most often researchers compute the Content Validity Index (CVI) for each item in the instrument as rated by two or more experts in order to determine how valid the study instrument is. Amin (2005) says, if the CVI is 0.70 and above, the instrument can then be considered valid. In this study, the CVI of 0.91 implies that the instrument was valid.

3.8.2 Reliability

Reliability enhances repeatability and generalization of study findings. It can be ensured through: test re-retest method and internal consistency method. In the test retest method, the researcher pretested twice the instrument on 20 households in Kampala and then correlates the recorded scores of the two administrations (T_1 and T_2) to check consistency, clarity, completeness; and weakness in administration and distribution of the questionnaires. According to Amin (2005), a correlation coefficient of 0.70 and above is often recommended in most studies.

Secondly, the study used internal consistency method. Cronbach's alpha was used in the actual study to determine the internal consistency of the instrument. Cronbach's alpha (α) measures the internal consistency that is, how closely related a set of items are as a group. The higher the α-

value, the more reliable the instruments are considered. A commonly accepted rule for describing internal consistency using Cronbach's alpha is as follows (Kline, 2000).

Table 3.3: Interpretation of Cronbach's Alpha Results

Cronbach's alpha (α)	Internal consistency
0.91-1.00	Excellent
0.81-0.90	Good
0.71-0.80	Acceptable
0.61-0.70	Questionable
0.51-0.60	Poor
$0.50 \leq \alpha$	Unacceptable

Table 3.4: Reliability Results

Variables	Number of items	Cronbach's alpha	Interpretation
Climate variability	8	0.810	Good
Household food security	16	0.899	Good

The results presented in table 3.4 above shows that there is high level of internal consistency among the main variables of the study thus indicating high level of reliability of the instruments.

3.9 Data Collection Procedure

An introduction letter was obtained from the College of Humanities and Social Sciences of Kampala International University (KIU) for the researcher to solicit approval to conduct the study from Masisi territory. The researcher administered the questionnaires himself so as to explain any irregularities properly to the respondents and adequately orient them about the study and why it is being carried out. The respondents were requested to sign the informed consent form. They were also guided on how to fill the questionnaires, and the importance of answering every item of the questionnaire without leaving any part unanswered. The respondents were requested to kindly respond to the questionnaire on time. The researcher retrieved the filled questionnaires within one week. After retrieving them back, the researcher thoroughly checked them to ensure that all items were adequately answered by the respondents.

3.9 Data Analysis

After retrieving back the questionnaire and collecting the required data, it was then prepared for analysis by using Statistical Package for Social Scientists (IBM SPSS, version 22.0) software. In this process, the data underwent data editing which involved checking the filled questionnaires for any omissions or mistakes; then data coding which involved giving each item of the questionnaire or variable a code to be used when imputing the data into the computer, and lastly data entry into the computer for analysis.

The analysis was conducted in the following manner: frequency counts, percentage distributions and mean were used to describe the demography of the respondents and variables such as climate variability, food security and adaptation strategies. Linear regression analysis was used to determine the impact of climate variability on food security.

Qualitative data was analyzed by grouping similar kinds of information together in categories and relating different ideas and themes to one another. The researcher used overcharging themes in the data which helped him in finding possible and plausible explanations for the findings. Finally, the researcher quoted the words of each key interview informant who participated in an interview so as not to distort the content matter by explaining it in his own understanding. The quotes were put between quotation marks so as to distinguish it from the rest of the texts in the study.

3.10 Ethical Consideration

After confirming the validity and reliability of the research instruments, the researcher got an introduction letter from the College of Humanities and Economics of KIU to collect data from Masisi territory. Prior to commencing the survey in this study, all participants were made aware of the research significance and type of information being collected. The researcher explained to the participants that their participation in the study was based on their own interest, and that they were under no obligation to be coerced to participate, and that they could decline to participate at any time. Their right to withdraw at any time during the survey was explicitly stated. Furthermore, data confidentiality was observed and no name of any participant was included in the final write up of this study.

CHAPTER FOUR
DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.0 Introduction

This chapter presents the analysis of the data gathered and interpretation thereof. It gives the demographic characteristics of the respondents and variables used.

4.1 Demographic Characteristics of the Respondents

This section determines the demographic characteristics of the respondents. To achieve it, questionnaires were distributed to capture these responses. Frequencies and percentage distribution tables were employed to summarize the demographic characteristics of the respondents in terms of gender, age, education level, income level, and number of family members. The following tables give the summary of the demographic characteristics of the respondents.

Table 4.1: Gender of the Respondents

Gender	**Frequency**	**Percent (%)**
Male	68	39.8
Female	103	60.2
Total	**171**	**100.0**
Age		
20-29 years	12	7.0
30-39 years	72	42.1
40-49 years	74	43.3
50-59 years	13	7.6
Total	**171**	**100.0**
Education Level		
Not Educated	45	26.3
Primary	70	40.9
Secondary	34	19.9
Post-secondary	22	12.9
Total	**171**	**100.0**
Income Level		
Less than $50	25	14.6
$50-$150	112	65.5
$150-$350	34	19.9
$350-$500	0	0.0
More than $500	0	0.0
Total	**171**	**100.0**
Family members		
1-5 members	53	31.0
5-10 members	98	57.3
More than 10 members	20	11.7
Total	**171**	**100.0**

Source: primary data, 2019

The results presented in table 4.1 revealed that majority, 60.2% of the respondents were female while the male respondents were 39.8%. The dominance of the female respondents was attributed to the fact that they are the ones who were available at home during data collection and they are the ones who are most knowledgeable regarding aspect of food security in the households.

Similarly, table 4.1 revealed that majority, 43.3% of the respondents were within the age group of 40-49 years, followed by 42.1% who were within the age group of 30-39 years, while those within the age group of 50-59 years and 20-29 years were represented by 7.6% and 7% respectively. None of the respondents was more than 60 years. The dominance of the respondents within the age group of 40-49 years implies that most households have grown up people who struggle to sustain their families with affordable food supply.

Furthermore, table 4.1 revealed that majority, 40.9% of the respondents were educated only up to primary level, followed by 26.3% of the respondents who were not educated at all., those with secondary and post-secondary education were represented by 19.9% and 12.9% respectively. The dominance of the respondents with primary education is attributed to the decades of insecurity and the ethnic conflicts in the region which has left many people to drop out of school.

Likewise table 4.1 revealed that majority, 65.5%, of the respondents earned between $50-$150, followed by 19.9% of the respondents whose monthly income was $150-$350, while those whose monthly income was less than $50 were represented by 14.6% respectively. The dominance of the respondents with monthly income of $50-$150 is attributed to the high level of poverty in the area promoted by insecurity, unemployment, lack of education and adverse climate changes. Thus people cannot be gainfully employed in formal sector to get better paying jobs.

Lastly, table 4.1 revealed that majority, 57.3% of the respondents had between 5-10 family members, followed by 31% who had 1-5 family members and 11.7% of the respondents had more than 10 family members. The dominance of the respondents with 5-10 family members is attributed to extended family setting most common in the African tradition. In addition, most families have more than one wife, that is to say, there is a common practice of polygamy among African traditions thus leading to big number of family members.

4.2 Descriptive Statistics

4.2.1 Climate Variability

This section looks at climate variability in terms of rainfall variability and temperature variability. Frequency, percentage, and mean were used to describe the findings of climate variability in Masisi teritorry. On a range of 5-1, the following abbreviations were adopted: Strongly Agree (SA), Agree (A), Don't Know (DN), Disagree (D), and Strongly Disagree (SD). Table 4.2 gives the summary of the findings.

Table 4.2: Climate variability

Climate variability	**SD (%)**	**D (%)**	**DN (%)**	**A (%)**	**SA (%)**	**Mean**
Rainfall variability						
You experience frequent floods that destroy your crops and animals.	10(5.8)	14(8.2)	4(2.3)	97(56.7)	46(26.9)	3.91
You have experienced soil erosions due to flooding.	8(4.7)	9(5.3)	17(9.9)	97(56.7)	40(23.4)	3.89
You have experienced increased weed growth due to frequent floods.	9(5.3)	14(8.2)	38(22.2)	93(54.4)	17(9.9)	3.80
You have experienced loss of vegetation due to flooding.	15(8.8)	34(19.9)	29(17.0)	73(42.7)	20(11.7)	3.29
Temperature variability						
You have experienced decrease in crop yields due to prolonged drought.	9(5.3)	5(2.9)	10(5.8)	98(57.3)	49(28.7)	4.01
Your livestock have died due to prolonged drought.	8(4.7)	10(5.8)	7(4.1)	96(56.1)	50(29.2)	3.99
You have experienced reduction in soil nutrients due to drought.	8(4.7)	9(5.3)	16(9.4)	87(50.9)	51(29.8)	3.96
You have experienced reduction in soil nutrients due to drought.	3(1.8)	12(7.0)	30(17.5)	82(48.0)	44(25.7)	3.89

Source: primary data, 2019

The results presented in table 4.2 revealed that majority, 56.7% of the respondent agreed that they experience frequent floods that destroy their crops and animals (mean=3.91). Similarly, 56.7% of the respondents agreed that they have experienced soil erosions due to flooding

(mean=3.89). In addition, 54.4% of the respondents agreed that they have experienced increased weed growth due to frequent floods (mean=3.80). Furthermore, 42.7% of the respondents agreed that they have experienced loss of vegetation due to flooding (mean=3.29).

Correspondingly, table 4.2 revealed that majority, 57.3% of the respondents agreed that they have experienced decrease in crop yields due to prolonged drought (mean=4.01). Equally, 56.1% of the respondents agreed that their livestock have died due to prolonged drought (mean=3.99). In the same vein, 50.9% of the respondents agreed that they have experienced reduction in soil nutrients due to drought (mean=3.96). Lastly, 48% of the respondents agreed that they have experienced reduction in soil nutrients due to drought (mean=3.89).

The above responses imply that the adverse effects of climate variability in terms of flooding and extreme temperature such as drought have brought about great losses to the farmers. This is because crops and animals alike have dies in the process and several farmers do not have the capacity to independently address such climate variability effects.

In order to understand in-depth the adverse effects of climate variability, the researcher engaged key informants in an interview and the extract of their responses were summarized as below:

> *Unlike at first when the onset of the farming season was in May, this time it is in June; and, at times, we even start the farming season in July. The raining season is actually moving forward* (extensive farmer).

Commenting on the decreasing trend in the rainfall pattern, a farmer observed:

> *These days, the rainwater is not adequate for the crops. It rains for only three months and it stops. Sometimes it even rains for two-and-a-half months. How can we have a good harvest from the crops we have planted judging from the fact that maize needs adequate rainwater to mature?* (extensive farmer).

The increasing night temperatures had implications for crop yield, as many of the crops could not tolerate the changes in temperature. Our key informant explained how increasing daytime temperatures were affecting farming activities:

> *Farmers in this part of the country are suffering from the increasing temperatures because their crops are withering from the scorching effect of the sun. Maize farmers are*

always seriously affected because the temperature affects flowering, which in turns affect the ability of the maize plant to produce good yield (village councilor).

While farmers were worried about increasing daytime temperature and its effects on crop yield, they were particularly worried about how high temperatures during the day limited their ability to work for longer hours and at the same time its effect on their health. As a farmer noted during the interview:

These days if you want to work for longer hours, then you must come to the farm very early in the morning. If you come late, the sun will not allow you to work because the rays are hard-hitting. If you want to continue and work, you may fall sick eventually (extensive farmer).

The majority of the farmers who participated in the study shared similar sentiments.

4.2.2 Household Food Security

This section looks at household food security in terms of food availability, food accessibility, and food utilization. Frequency, percentage, and mean were used to describe the findings of household food security in Masisi teritorry. On a range of 5-1, the following abbreviations were adopted: Strongly Agree (SA), Agree (A), Don't Know (DN), Disagree (D), and Strongly Disagree (SD). Table 4.3 gives the summary of the findings.

Table 4.3: Household Food Security

Household Food Security	SD (%)	D (%)	DN (%)	A (%)	SA (%)	Mean
Food availability						
Was there any day during the last 3 months that you or any other adult in your home skipped a meal because of lack of food?	8(4.7)	6(3.5)	13(7.6)	144(84.2)	0(0)	3.71
During the last 3 months, were you worried about running out of food?	6(3.5)	15(8.8)	5(2.9)	145(84.8)	0(0)	3.69
Did your home run out of food at any time during the last 3 months?	11(6.4)	8(4.7)	21(12.3)	131(76.6)	0(0)	3.59
Did you or anybody in your home usually have to eat the same foods almost every day during the last 3 months?	5(2.9)	19(11.1)	18(10.5)	129(75.4)	0(0)	3.58
Was your home unable to eat the kinds of food that make you healthy at any time during the last 3 months?	13(7.6)	37(21.6)	35(20.5)	86(50.3)	0(0)	3.13
Food accessibility						
During the last 3 months did any adult in your home eat less food than what they needed because there was not enough food?	3(1.8)	12(7.0)	9(5.3)	147(86.0)	0(0)	3.75
In the last 3 months, were there any months when your household did not have enough food to meet the household's food needs?	5(2.9)	9(5.3)	13(7.6)	144(84.2)	0(0)	3.73
Was there any day when you or any other adult in your home did not eat for a whole day or just ate once during the day because there was not enough food during the last 3 months?	10(5.8)	12(7.0)	5(2.9)	144(84.2)	0(0)	3.65
During the last 3 months, did you do things that you would have preferred not to do, such as begging or sending children to work, to get food?	9(5.3)	10(5.8)	16(9.4)	136(79.5)	0(0)	3.63
During the last 3 months was there any day when you or any other adult in your home felt hungry but did not eat because there was not enough food?	4(2.3)	15(8.8)	28(16.4)	124(72.5)	0(0)	3.59
Food utilization						
In the last 3 months, did you fall sick?	7(4.1)	11(6.4)	20(11.7)	133(77.8)	0(0)	3.63
During the last 3months, have you drinking clean and boiled water?	7(4.1)	16(9.4)	36(21.1)	112(65.5)	0(0)	3.48
During the last 3months, have you been eating food which was well cooked and well covered to keep it safe?	15(8.8)	11(6.4)	27(15.8)	118(69.0)	0(0)	3.45
During the last 3months, have you been eating variety of food rich in nutrients?	10(5.8)	9(5.3)	0(0)	152(88.9)	0(0)	2.83
During the last 3months, have you been using clean toilet or ventilated pit latrine?	10(5.8)	10(5.8)	0(0)	151(88.3)	0(0)	2.82
During the last 3months, have you been depositing your solid and liquid wastes in safe and protected area/container?	26(15.2)	119(69.6)	0(0)	26(15.2)	0(0)	2.54

Source: primary data, 2019

In regard to food availability, majority (84.2%) of the respondents agreed that in the past 3 months, they or an adult in their home skipped a meal because of lack of food (mean=3.71).

Similarly, 84.8% of the respondents agreed that during the last 3 months, they were worried about running out of food (mean=3.69). In addition, 76.6% of the respondents agreed that at some point in time in the past 3 months, they had run out of food (mean=3.59). Equally, 75.4% of the respondents agreed that they had eaten the same type of food every day in the last 3 months (mean=3.58). Lastly, 50.3% of the respondents agreed that they were unable to eat the kinds of food that would make them healthy at any time during the last 3 months (mean=3.13).

The above responses imply that lack of food availability is prevalent in Masisi, this is because most of the households testified that they were unable to sustain three meals a day, often worried of running out of food, and at times running out of food, and sometimes unable to eat healthy food. This could be because of insecurity caused by prolonged conflicts, drastic climatic changes such as prolong drought and floods.

In regard to food accessibility, majority (86%) of the respondents agreed that during the last 3 months they had eaten less food than what they needed because there was not enough food (mean=3.75). Likewise, 84.2% of the respondents agreed that in the last 3 months, there were some months when they did not have enough food to meet the household's food needs (mean=3.73). In addition, 84.2% of the respondents agreed that there was a time in the last three months that they had not eaten for a whole day because there was not enough food (mean=3.65). Similarly, 79.5% of the respondents agreed that during the last 3 months, they did things that they would have preferred not to do, such as begging or sending children to work, to get food (mean=3.63). Furthermore, respondents agreed that during the last 3 months, there was a day when they felt hungry but did not eat because there was not enough food (mean=3.59).

This implies that lack of accessibility of food in most households in Masisi is evident since most households are eating less food, some are not having enough food to eat, others are eating once a day, while others resort to begging for food against their will.

In regard to food utilization, majority (77.8%) of the respondents agreed that they had fallen sick in the last 3 months (mean=3.63). However, 65.5% of the respondents agreed that during the last 3months, they had drank clean and boiled water (mean=3.48). Furthermore, 88.9% of the respondents agreed that during the last 3months, they had been eating food which was well cooked and well covered to keep it safe (mean=3.45). In addition, 88.9% of the respondents

agreed that during the last 3months, they had been eating variety of food rich in nutrients (mean=2.83). Similarly, 88.3% of the respondents agreed that during the last 3months, they had been using clean toilet or ventilated pit latrine (mean=2.82). On the contrary, 69.6% of the respondents disagreed that during the last 3months, they had been depositing their solid and liquid wastes in safe and protected area/container (mean=2.54).

The above responses imply that most households were not sickly because they had been practicing good sanitation and hygiene which included boiling water, cooking food well and covering it for safety reasons. However, some sanitation and hygiene practices were not observed by a large number of households such as proper disposal of wastes or having a well ventilated pit latrine. This could because poverty and low level of education in the area.

In order to substantiate the findings from the questionnaire, the researcher asked the key informants in an interview of the food security situations in their households, their responses were summarized as below:

> *It is not easy to get food in this area because of climate changes and internal conflicts. Sometimes if we plant our crops, floods and prolong droughts end up destroying them. So it is not like we are lazy and we don't want to work, but we are surrounded by very many unfriendly circumstances* (extensive farmer).

> *In this village, the road network is very poor so we cannot take our food to the market to sell and get some money to buy diet oriented food. We are instead forced to live on the food which we have grown. In some areas, floods have washed away bridges and feeder-roads thus making us cut off from the market* (village councilor).

> *Generally since drought has been persistent in the past years in this district, most families have become vulnerable to hunger. Actually most people have migrated to Rwanda and Uganda in search for food; but those of us who have remained, we really have no much money to buy luxury food. But at least we can afford posho, beans, cassava and sweet potatoes. In this community, foods like rice, banana, Irish, fish, meat are seen as a luxury* (village councilor).

The above responses imply that food availability and access are generally affecting the general food security of the people in Masisi teritorry.

4.3 The impact of climate variability on the food availability of the households in Masisi

The first objective of this study was to assess the impact of climate variability on the food availability of the households in Masisi, DRC. Table 4.4 gives the summary of the findings.

Table 4.4: The impact of climate variability on the food availability of the households in Masisi

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.683[a]	.467	.464	.40091	.467	148.003	1	169	.000

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.788	1	23.788	148.003	.000[b]
	Residual	27.163	169	.161		
	Total	50.952	170			

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.317	.169		7.789	.000
	Climate variability	.584	.048	.683	12.166	.000

a. Dependent Variable: food availability

Table 4.4 shows that climate variability significantly impacts on food availability at Masisi teritorry. This is attributed to the fact that climate variability can explain a total variance of 46.4% of food availability (Adjusted R Square=0.467, p=0.00). This implies that rainfall variability and temperature variability has an adverse effect on food availability.

Furthermore, the study revealed that the regression model was a good fit for predicting the effect of climate variability on food availability (F=148.003, p=0.000). Similarly, the study revealed that every unit change in climate variability would significantly predict a variance in food availability by 68.3% (Beta=0.683, p=0.000). This implies that drought or flooding causes more than 68% loses in food availability thus leading to food insecurity.

4.4 The impact of climate variability on food accessibility of the households in Masisi

The second objective of this study was to evaluate the impact of climate variability on food accessibility of the households in Masisi, DRC. Table 4.5 gives the summary of the findings.

Table 4.5: The impact of climate variability on food accessibility of the households in Masisi

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.608[a]	.370	.366	.38993	.370	99.209	1	169	.000

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.085	1	15.085	99.209	.000[b]
	Residual	25.696	169	.152		
	Total	40.781	170			

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.544	.164		9.388	.000
	Climate variability	.465	.047	.608	9.960	.000

a. Dependent Variable: food accessibility

Table 4.5 shows that climate variability significantly impacts on food accessibility at Masisi teritorry. This is attributed to the fact that climate variability can explain a total variance of 36.6% of food accessibility (Adjusted R Square=0.366, p=0.00). This implies that rainfall variability and temperature variability has an adverse effect on food accessibility.

Furthermore, the study revealed that the regression model was a good fit for predicting the effect of climate variability on food accessibility (F=99.209, p=0.000). Similarly, the study revealed that every unit change in climate variability would significantly predict a variance in food accessibility by 60.8% (Beta=0.608, p=0.000). This implies that drought or flooding causes more than 60% loses in food accessibility thus leading to food insecurity.

4.5 The impact of climate variability on food utilization of the households in Masisi, DRC

The third objective of this study was to assess the impact of climate variability on food utilization of the households in Masisi, DRC. Table 4.6 gives the summary of the findings.

Table 4.6: The impact of climate variability on food utilization of the households in Masisi, DRC

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.691[a]	.478	.475	.37671	.478	154.587	1	169	.000

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.937	1	21.937	154.587	.000[b]
	Residual	23.983	169	.142		
	Total	45.920	170			

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.239	.159		7.796	.000
	Climate variability	.560	.045	.691	12.433	.000

a. Dependent Variable: food utilization

Table 4.6 shows that climate variability significantly impacts on food utilization at Masisi teritorry. This is attributed to the fact that climate variability can explain a total variance of 47.5% of food utilization (Adjusted R Square=0.475, p=0.00). This implies that rainfall variability and temperature variability has an adverse effect on food utilization.

Furthermore, the study revealed that the regression model was a good fit for predicting the effect of climate variability on food utilization (F=154.587, p=0.000). Similarly, the study revealed that every unit change in climate variability would significantly predict a variance in food utilization by 69.1% (Beta=0.691, p=0.000). This implies that drought or flooding has the capacity to influence reduction in food utilization by 69% thus leading to food insecurity.

CHAPTER FIVE
DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the discussion of the study guided by the study objectives. The discussion of this study findings were done by reviewing related literature, and comparing and contrasting with other previous studies. The study was later concluded and appropriate recommendations accruing from the findings were made.

5.1 Discussion of the Findings

5.1.1 The impact of climate variability on the food availability of the households in Masisi

The first objective of this study was to assess the impact of climate variability on the food availability of the households in Masisi, DRC. The study revealed that climate variability significantly impacts on food availability at Masisi teritorry (Adjusted R Square=0.467, p=0.00). This study is in line with the findings of Sianungu (2015) who found that access to food depends on the physical factors, as well as social and economic factors. This is because, after food is produced, it needs to be moved from the point of production to the point of consumption. This often depends on transport systems. According to IPCC (2001), increased rainfall, flooding and mud may cause several roads to be impassable. Moreover, Kydd et al. (2004) found that rainfall variability contributes to underinvestment and hence to long-run agricultural stagnation and rural poverty in countries that are dependent on rain-fed agriculture. This leads to a decrease in food availability and accessibility.

Similarly, Shisanya (2015) examined the interaction between household food security and rural farming communities' perception of climate change in uMzinyathi District and found that Households assessed (97%) were found to be severely food insecure while 3% were moderately food insecure. Households were worried about the negative impacts of climate change which included droughts, floods and soil erosion. Households who were found to be vulnerable to climate change recorded high levels of food insecurity.

Furthermore, the findings confirm indications that erratic climate change will have profound negatives impacts on rural household food security. As expected, household that were vulnerable to climate change showed significant levels of food insecurity. These households had very

limited resource that could be used in addressing food security, confirming (Aggarwal and Singh 2010) observations that rural communities are prone to the devastating impacts of climate change resulting from low adaptation capabilities. Decreasing soil fertility resulting soil erosion and influenced by the erratic weather patterns spells doom for household food security. Yield from farmers have over years been decreasing as a result of loss of top soil that is necessary for improved yields. Households preferred to use different methods to cope with the changing climate with resulting decrease in household food security.

5.1.2 The impact of climate variability on food accessibility of the households in Masisi

The second objective of this study was to evaluate the impact of climate variability on food accessibility of the households in Masisi, DRC. The study revealed that climate variability significantly impacts on food accessibility at Masisi teritorry (Adjusted R Square=0.366, p=0.00). This was attributed to the fact that majority of households in Masisi teritorry engage in crop and/or livestock production as a primary livelihood and yet widespread drought and infrequent rainfalls limit households' capacities to consistently engage in farming activities and access market food their products thus limiting their access to food. In line with findings of this study, a study by WFP (2014) revealed that agricultural production in north Kivu (where Masisi teritorry is located) faces several constraints that prevent households from optimizing yields and income gains. According to WFP (2014), these constraints include limited access to land, market, extension services, improved seed and other inputs, and pests and diseases.

Furthermore, a study by WFP (2014) revealed that in North Kivu, 54% of the population reported engaging in production. Of this 54%, 41% produced on less than 2 hectares of land and the remaining 13% produced on more than 2 hectares. This implies that most households cannot produce enough food that can be accessible to family members throughout the year.

Furthermore, in line with the results of this study is a study by Oxfam (2015) which found that access to land and control of resources have been driving factors in Masisi teritorry. This is because lack of land ownership greatly affected broader agricultural production. Since the majority of men and women do not own their farmland and may become displaced, there is little incentive for them to adopt improved practices. For example, recent survey data from Katanga and Masisi teritorry suggested that access to land and asset ownership by men and women remained a widespread problem (Oxfam 2015).

Moreover, ADRA's (2012) survey indicated that the ongoing conflict in the region has severely affected agricultural production, but years of neglect from the central government alongside challenges such as climate variability in terms of frequent flooding, poor planting practices, access to improved seeds, markets, and crop disease/pests have also turned an otherwise breadbasket into one that relies heavily on imported foodstuffs and emergency food aid. Crop diseases such as cassava mosaic disease (CMD), Banana Xanthomonas Wilt (BXW), Black Sigatoka and Fusarium Wilt, and Banana Bunchy Top Virus (BBTV) have decimated production of these crops since they were first identified.

4.5 The impact of climate variability on food utilization of the households in Masisi, DRC

The third objective of this study was to assess the impact of climate variability on food utilization of the households in Masisi, DRC. The study revealed that climate variability significantly impacts on food utilization at Masisi teritorry (Adjusted R Square=0.475, p=0.00). This was attributed to the fact that most households were not using good sanitation and hygiene practices such as proper disposal of wastes or having a well ventilated pit latrine. This could be because of poverty and low level of education in the area.

This study agrees with the findings of Izaurralde (2009) who found that food utilization changes with seasonal variation and food availability changes throughout the year. The author further found that the hungry season is the time before the planted crops are ready to be eaten. Thus, if there has been a drought and food availability is low, the range of food available often decreases, and so the meal frequency can decrease and the balance of nutrients can be inadequate. This can lead to malnutrition in children.

Furthermore, Wang and Hijmans (2019) found that climate variability has impact on food utility indirectly. For example, if there are hot dry days, crops and vegetables may be dried so that they can be used later in the year. At the same time as seasonal crop production, many households face fluctuations in cash and in-kind income, both within a single year and from year to year. Agricultural households may face seasonal fluctuations in income related to crop cycles. Year-to-year fluctuations in income can result from varying agro-climatic conditions and climate variability.

5.2 Conclusion

Objective one: Climate variability significantly impacts on food availability in Masisi territory. This is largely because of increase in temperature variability and rainfall variability thus affecting planting and harvesting seasons. This has often led farmers to lose because of the adverse effects of the erratic climate variability thus causing low food availability.

Objective two: Climate variability significantly impacts on food accessibility in Masisi territory. This is attributed to the effect of rainfall flooding that wash away some road networks thus making markets in-accessible. Several times, some regions in Masisi territory can have food but because of poor road networks, it makes it impossible for such food to be accessible because it cannot be brought to the market. Similarly prolong droughts makes it more expensive to transport food to different parts of Masisi territory because of the high temperature thus making food in-accessible.

Objective three: Climate variability significantly impacts on food utilization in Masisi territory. Food at times is available and accessible in some regions of Masisi territory but because of frequent droughts and floods, it makes people unable to utilize the food properly. For instance, during dry seasons, people may end up growing drought resistant crops which eventually limit them from feeding on complete dietary food thus causing malnutrition among children. In other words, poor utilization of the available and accessible food affects the physical growth of both children and adults.

5.3 Contribution to Knowledge

Several studies have been done in the subject of climate change and food security but with mixed results (Obwocha 2015; Yagoub et al., 2017; Shisanya 2015). The current study has added to the body of knowledge that climate variability influences food security in Masisi. This is to mean, the prevalence of prolonged drought and floods affects the food security of the people by destroying food crops and livestock. However, the use of proper adaptation strategies by the households plays a very significant role.

5.4 Recommendations

Objective One

The local communities and households should adopt adaptation strategies such as promoting home gardens and small animal husbandry, improving food preservation and home or community processing technologies such as community silos where every household contributes 10 percent of maize or beans harvest for storage so that during drought food is available for the members of the community.

Furthermore, farmers should adopt the use of modified crops that have the capacity to resist natural occurrences and sudden climatic shocks curbing the pressure on the environment and in turn increasing the production of food without getting affected by climate.

Likewise, the metrological personnel in Masisi teritorry should adopt the use of Normalized Differential Vegetation Index NDVI indices from satellite data to effectively monitor climatic conditions and relate with food security. NDVI has been proved to correlate with rainfall received available on a continuous basis and can be used in monitoring drought on near real time basis as well as in trend analysis. NDVI data can be applied in both quantitative and qualitative analysis of drought. The data can be used to assess drought duration, intensity and spatial distribution of drought conditions hence be useful in drought management.

Objective two

The local government of Masisi teritorry with the support of the central government and donor communities should build permanent roads and bridges that are strong enough to withstand flooding during rainy seasons and dust during drought seasons.

In addition, farmers should use advanced farming techniques such as irrigation systems and cultivation of different crop varieties that are not sensitive to climate change in order to cope in a better fashion, with the climatic shocks such as droughts or floods.

Objective three

The government of Masisi teritorry with the help of the central government of DRC should promote the production and consumption of micronutrient-rich foods over the long-term, while also taking into consideration the displacement of the population due to insecurity and conflict

and lack of land tenure in the short and medium-term when considering the options available for the prevention of poor food utilization by the community members.

Similarly, the government should expand and improve WASH infrastructure as this is a prerequisite to preventing poor sanitation and hygiene in households. This can be done by constructing permanent infrastructure in the communities, as well as simple structures in the households (such as tippy taps), in addition to advocating for changed hygiene behaviors.

5.5 Areas for Further Studies

There is need for a further study on the effects of climate change adaptation strategies on food crop (cassava and maize) production efficiency in Masisi teritorry, DRC.

In addition, a further study is imperative on climate variability and food coping strategies of the rural people in Masisi teritorry, DRC.

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APPENDICES

APPENDIX I: INTRODUCTION LETTER

I am a Masters candidate for Development Studies at Kampala International University undertaking a research study on the topic **"The Climate Variability and Household Food Security in North Kivu Province, Masisi, DR Congo"**. In view of this, I request you to participate in this study. Kindly answer this questionnaire without leaving any question unanswered. Please be assured that the information you give will be treated with utmost confidentiality and will be used for academic purpose only. Before answering this questionnaire kindly read and sign the attached informed consent.

Thank you very much in advance.

Yours faithfully

…….

Mutabazi Harera Paul

APPENDIX II: CONSENT FORM

I am giving my consent to be part of the research study of Mr. Mutabazi Harera Paul on the topic: **"The Climate Variability and Household Food Security in North Kivu Province, Masisi, DR Congo"**.

		Please tick
1	I confirm I have read and understood the information provided for the above research and had the opportunity to ask questions.	☐
2	I understand my participation is voluntary and that I am free to Withdraw at any time without giving a reason.	☐
3	I agree to take part in the research	☐

APPENDIX III: QUESTIONNAIRE

Section A: Profile of the Respondents

1. Gender

a) Male ☐ b) Female ☐

2. Age

a) 20-29 years ☐ b) 30-39 years ☐

c) 40-49 years ☐ d) 50-59 years ☐

e) 60 years and above ☐

3. Education Level

a) Not educated ☐ b) primary level ☐

c) Secondary level ☐ d) Post-secondary level ☐

4. Monthly income

a) Less than $50 ☐ b) $50-$150 ☐

c) $150-$350 ☐ d) $350-500 ☐

e) More than $500 ☐

5. Number of family members

a) 1-5 members ☐ b) 5-10 members ☐

c) More than 10 members ☐

Section B: Climate Variability

Instruction: please use the following ratings to give your opinion on the following statements regarding climate variability in your household. **1**=strongly disagree, **2**=disagree, **3**=not sure, **4**=agree, **5**=strongly agree.

#	Climate variability	1	2	3	4	5
A	**Rainfall variability**					
1	You experience frequent floods that destroy your crops and animals.					
2	You have experienced soil erosions due to flooding.					
3	You have experienced loss of vegetation due to flooding.					
4	You have experienced increased weed growth due to frequent floods.					
B	**Temperature variability**					
1	You have experienced decrease in crop yields due to prolonged drought.					
2	You have experienced reduction in soil moisture due to drought.					
3	You have experienced reduction in soil nutrients due to drought.					
4	Your livestock have died due to prolonged drought.					

Section C: Food Security

Instruction: please use the following ratings to give your opinion on the following statements regarding food security in your household. **1**=strongly disagree, **2**=disagree, **3**=not sure, **4**=agree, **5**=strongly agree.

	Food Security	**1**	**2**	**3**	**4**	**5**
A	**Food Availability**					
1	During the last 3 months, were you worried about running out of food?					
2	Did your home run out of food at any time during the last 3 months?					
3	Was your home unable to eat the kinds of food that make you healthy at any time during the last 3 months?					
4	Did you or anybody in your home usually have to eat the same foods almost every day during the last 3 months?					
5	Was there any day during the last 3 months that you or any other adult in your home skipped a meal because of lack of food?					
B	**Food Accessibility**					
1	During the last 3 months did any adult in your home eat less food than what they needed because there was not enough food?					
2	During the last 3 months was there any day when you or any other adult in your home felt hungry but did not eat because there was not enough food?					
3	Was there any day when you or any other adult in your home did not eat for a whole day or just ate once during the day because there was not enough food during the last 3 months?					
4	During the last 3 months, did you do things that you would have preferred not to do, such as begging or sending children to work, to get food?					
5	In the last 3 months, were there any months when your household did not have enough food to meet the household's food needs?					
C	**Food Utilization**					

1	In the last 3 months, did you fall sick?					
2	During the last 3months, have you been eating variety of food rich in nutrients?					
3	During the last 3months, have you been eating food which was well cooked and well covered to keep it safe?					
4	During the last 3months, have you been drinking clean and boiled water?					
5	During the last 3months, have you been using clean toilet or ventilated pit latrine?					
6	During the last 3months, have you been depositing your solid and liquid wastes in safe and protected area/container?					

APPENDIX IV: INTERVIEW

1. How has climate variability affected your farming?
2. What has been the food security situation of your household in the past three months?
3. What adaptation strategies has your household used to reduce the effect of climate variability in your province?

THE END