IMPACTS OF CLIMATE CHANGE AND CLIMATE VARIABILITY ON AGRICULTURE AND HOUSEHOLD FOOD SECURITY IN KAZUNGULA DISTRICT

By

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DECLARATION

I, Lusajo Mwakalesi Ambukege, declare that this dissertation represents my own work and has not been submitted at this or any other University for award of a degree. Furthermore, this dissertation does not incorporate any published work or materials from another dissertation.

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APPROVAL

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ABSTRACT

The earth's climate system has changed due to natural phenomena and anthropogenic activities resulting into increased atmospheric concentration of greenhouse gasses thus impacting negatively on agricultural production and food security. Climate change and climate variability is likely to be the major cause for low food production, food insecurity, crop failure, collapse of fisheries and livestock deaths due to alterations in temperature and rainfall. Zambia's high dependency on rain-fed agriculture will make it more vulnerable to climate change and climate variability. Kazungula district has experienced decreased crop production due to extreme climate events such extreme temperatures and precipitation which has a negative bearing on the four pillars of household food security. Therefore, the main objective of this study was to assess the impacts of climate change and climate variability on agriculture and household food security in Kazungula district. This research utilized both qualitative and quantitative methods of research. Qualitative and quantitative data was collected through household structured questionnaires, focus group discussions and key informant interviews. Secondary data on rainfall, temperature and agricultural production statistics was obtained from the Zambia Meteorological Department, Ministry of Agriculture and the Swedish Meteorological and Hydrological Institute. Research findings suggest that climate change and climate variability is real and parameters such as temperature and rainfall have changed in the last 35 years (1963- 1993). For example temperature has increased by $2^{o}C$ while rainfall has decreased by 26. 5 percent in Kazungula district. Results further suggest that climate change and climate variability is a major problem for agriculture, household food security and rural livelihoods for majority of the people in Kazungula district. Climate change and climate variability has impacted negatively on the four pillars of food security (access, utilization, availability and stability). In terms of access, 64 percent of the households were food insecure, 91 percent were severely affected in terms of food availability, 84 percent had no carryover stocks affecting food stability and 73 percent were highly dependent on purchased cereals from outside Kazungula district with 72 percent accounting for vegetables and 62 percent for Sugar.

Research findings indicate that 58 percent of the households were exposed to climate change and climate variability, while the elderly aged between 45 and above (56 percent) were more vulnerable compared to the youth headed households aged between 20 and 34 years (40 percent). Majority of the households were highly dependent on emergency and crisis coping strategies that included sending children to eat from relatives, reducing number of meals eaten per day by adults and skipping meals. The study concludes that Kazungula is being impacted by the adverse impacts of climate change and climate variability which has a negative bearing on agriculture and household food security. The study strongly recommends promotion and adoption of adaption strategies to build the adaptive capacity of local communities to enhance crop production and household food security.

Key words: Climate Change, Climate Variability, Food Security, Agricultural Production.

DEDICATION

To my beloved wife- Brenda Nakamba, my children- Lukundo, Taizya, Suwilanji and Walusungu as well as my parents, Mr. Mwakalesi Ambukege and Mrs. Twisibile Ambukege.

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ACRONYMS

ADF	African Development Forum
CEEPA	Centre for Environmental Economics and Policy in Africa
CO_2	Carbon Dioxide
CORDEX	Coordinated Regional Climate Downscaling Experiment
CSO	Central Statistical Office
CSPro	Census and Survey Processing Software
DMMU	Disaster Management and Mitigation Unit
EN	Elnino
ENSO	Elnino Southern Oscillation
FAO	Food Agriculture Organization
FEWS-NET	Famine Early Warning Systems Network
GCM	Global Circulation Models
GDP	Gross Domestic Product
GHGs	Green House Gasses
IAPRI	Indaba Agricultural Research Institute
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter- Tropical Convergence Zone
MDG	Millennium Development Goals
MTENR	Ministry of Tourism, Environment and Natural Resources
NAPA	National Adaptation Programme of Action
NWFP	North- West Frontier Province
RCMs	Regional Climate Models
RS	Random Start
SADF	Seventh African Development Forum
SEA	Standard Enumeration Area
SMHI	Swedish Meteorological and Hydrological Institute
SO	Southern Oscillation
SPSS	Statistical Package for Social Sciences
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America

USAID	United States Agency for International Development
WFP	World Food Programme
WWF	Wild Wide Fund
ZVAC	Zambia Vulnerability Assessment Committee

CHAPTER 1

INTRODUCTION

1.1 Background

The earth's climate system has changed from the pre-industrial era to the present both globally and regionally due to natural phenomena and anthropogenic activities (Topcu *et al.,* 2010). Increased atmospheric concentrations of Greenhouse Gases (GHGs) such as Carbon dioxide (CO_2) and Methane (CH4) have altered the climate system which has resulted in greenhouse effect and global warming (International Food Policy Research Institute (IFPRI) (2010). Climate change may be due to internal or external natural processes, or persistent anthropogenic changes in the composition of the atmosphere or inland use (Intergovernmental Panel on Climate Change, (IPCC) (2014). According to the IPCC, climate change is defined as alterations in the state of the climate that can be identified by using statistical tests or changes in the mean and/or the variability of its properties and which persists for decades or longer (IPCC, 2014).

Climate change is possibly the most significant environmental challenge of our time and poses serious threats to the sustainable development of the emerging economies in developing countries (Christopher *et al*., 2013). According to the IPCC (2007), global climate change will impact on food and water security in a significant but highly uncertain manner in the coming years. There is overwhelming evidence that Sub-Saharan Africa like other regions in Africa will bear the consequences of climate change (Sofie, 2012). The 2016 Zambia National Climate Change Policy notes that countries like South Africa, Lesotho, Swaziland, Namibia, Mozambique and Angola experienced a 0.6°C to 1°C increase in temperature resulting into increased occurrence of droughts, floods and epidemics (Ministry of National Development Planning, 2016). The 2000 flood in Mozambique affected 2 million people, caused 500 deaths, displaced 329,000 people, while 1 million people were affected by food insecurity. Furthermore, the country recorded a reduced annual economic growth rate from 10 percent to 4 percent and crop destruction. The frequent occurrence of floods in Swaziland in 1984 caused widespread crop destruction, water contamination as well as property and infrastructure destruction (Mudenda, 2010). Similarly, the challenges for climate change in Zambia are substantial, due to its high dependence on climate sensitive natural resource sectors for food security, livelihoods and incomes.

In the coming years, climate change is likely to be one of the major causes for low food

production due to crop failure, collapse of fisheries and livestock deaths. These impacts are already causing economic problems and undermining food security and these are likely to become more severe (IFPRI, 2011 and Ahmed *et al*., 2009). Some of the climate change induced hazards affecting the rural communities include droughts, floods, epidemics, pests and environmental degradation (Zambia Vulnerability Assessment Committee, (ZVAC) (2005).

Most of the low-lying districts in Southern Province like Siavonga, Gwembe and Kazungula which are located in the valley areas are negatively impacted by climate change resulting into food insecurity due to the sensitivity of crops to timing, amount, and intensity of rainfall and temperature fluctuations (IPCC, 2007). In this regard, agricultural production in Kazungula district will have multiple impacts on other sectors of the economy such as health because sufficient nutrition determines productivity and agriculture failure results into food insecurity. The means and capacity to adapt to changes in climate are scarce due to low levels of human and economic development as well as high rates of poverty. These conditions combine to create a state of high vulnerability to climate change in Kazungula district.

Climate change and climate variability is projected to limit the potential for growth in the agriculture sector in Kazungula district. Low productivity and high levels of poverty, poor soils, poor market systems and unstable prices coupled with the effects of climate change will adversely affect household food security and rural livelihoods on which the majority of the people depend on for income generation (European Commission, 2011). Livestock will also be affected by drought and floods and will result into livestock deaths because droughts will affect vegetation growth. Therefore, this study seeks to establish the nature and typology of climate change induced hazards affecting agricultural production and food security as well as coping strategies for the people at household level in Kazungula district of Zambia.

1.2 Statement of the Problem

Climate change is a major problem for agriculture and household food security in Kazungula district. Due to climate change and climate variability, Kazungula has had consistent droughts and floods resulting into low crop yields and food insecurity. Annual average temperature has increased by 1.3°C and average annual rainfall has decreased by 1.9 mm since 1960. This has affected agricultural production and food security in Kazungula. Post harvest losses account for

30 percent and acute food insecurity levels stand at 76 percent (Thurlow *et al*., 2009).

Coping strategies to climate change remains a critical and significant goal to reverse the impacts of climate change on agriculture and household food security. However, the ability to cope with climate change induced hazards at household level are very low due to high poverty levels, low literacy levels and labor migration to the urban areas. However, most of the literature highlighting the impacts of climate change in Zambia have mainly focused on agriculture and food production at national level. Jain (2007), using the Ricardian model assessed the economic impacts of mean surface temperature increases and mean seasonal rainfall decrease on farming activities in Zambia. The study focused mainly on Zambia in general and on crop production but never looked at the four pillars of food security (access, availability, utilization and stability). Jemma *et al.* (2010), looked at the impacts of climate variability on agriculture but never gave a detailed analysis on climate change and food security. Vermenlon *et al.* (2010), gives a qualitative assessment of impacts of climate change on all sectors of the economy but negates the food security issue and coping strategies of rural households to impacts of climate change.

1.3 Aim

The aim of the study was to assess the impacts of climate change and climate variability on agriculture and household food security as well as the coping strategies of the people in Kazungula district.

1.4 Specific Objectives

The specific objectives of the study were:

i. To examine the nature of climate induced hazards affecting agriculture and household food security in Kazungula district.
ii. To evaluate the impacts of climate change and climate variability on agriculture and household food security in Kazungula district.
iii. To assess the coping strategies of households towards adverse impacts of climate change and climate variability in Kazungula district.

1.5 Research Questions

The study attempted to answer the following questions with specific reference to the objectives outlined above:

i. What is the nature of climate induced hazards affecting agriculture and household food security in Kazungula district?
ii. What are the impacts of climate change and climate variability induced hazards on agriculture and household food security in Kazungula district?
iii. How are the households coping with the adverse impacts of climate change and climate variability in Kazungula district?

1.6 Significance of the Study

The existing nascent literature in Kazungula on climate change and food security has very little empirical support. Climate change is a cross cutting issue affecting all sectors of the economy with agriculture and food security being the most vulnerable and affected sector by the impacts of climate change and climate variability. In view of the aforementioned, climate change is one of the problems facing rural communities in Kazungula. This research will therefore, help policy makers in Kazungula district to mainstream climate change and climate variability related issues in local plans. The significance of this study is that it will help district planners to develop long term adaptation strategies for rural households to increase agricultural production and household food security, particularly in Kazungula district and generally in Zambia. This study will further contribute to the knowledge on climate change and vulnerability and enhance long term adaptation strategies to climate change.

1.7 Organization of the Report

This report is structured in five chapters. Chapter 1 gives highlights on the background of the report, particularly on what other studies have looked at while Chapter 2 provides a theoretical framework on similar studies on impacts of climate change and climate variability on agricultural production and food security. Chapter 3 outlines the research methodology that was used in this study, Chapter 4 presents the results and discussion of the findings and Chapter 5 presents the conclusion and recommendations of the study based on the findings of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Climate Change and Food Security: Conceptualizing the Linkages

It is imperative to note that climate change is multifaceted and has been defined in different ways by different authors. For instance, the United Nations Framework on Climate Change Convention (UNFCCC) defines climate change as the change that can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over a comparable time period (UNFCCC, 1992). On the other hand, the IPCC defines climate change as a change in the state of the climate that can be identified by changes in the mean and or the variability of its properties and that persists for an extended period, typically periods or longer (IPCC, 2014). From these two definitions climate change can be defined as the change in the key properties or dimensions of the climate including the elements of weather such as average temperature, wind and rainfall over a longer period of time.

According to Kurukulasuriya *et al*. (2006), the main drivers of climate change are fossil fuel burning, deforestation and other human practices that increase the concentrations of GHGs in the atmosphere. The two main sources of these greenhouse emissions are from burning fossil fuels (oil, coal, and natural gas) and agricultural as well as other land use changes especially deforestation (Seventh African Development Forum, (SADF) (2010). The study by SADF (2010), contends that in Africa, agriculture is the major contributor of greenhouse emissions (34 percent) compared to other sectors such as manufacturing (10 percent) and other industrial processes (3 percent). Therefore, agriculture is both the contributor and victim of climate change effects (SADF, 2014). According to the IPCC (2014), the impacts of climate change varies from region to region depending on the mitigation measures and the ability to adapt. The impact of global warming has significant consequences for agricultural production and trade of developing countries as well as an increased risk of hunger.

Due to impacts of climate change, the total agricultural production could decline by 50 percent (Funk, 2005). Further, recurrent droughts and floods are becoming common in different continents with Africa been the most affected. Furthermore, climate change has a negative bearing on the four pillars of food security which are access, availability, utilization and stability.

Availability of agricultural products is affected by climate change through its impacts on crop yields, crop pests and diseases, income distribution and agricultural demand (Schmidhuler and Tubiello, 2007). In addition, stability of crop yields and food supplies is negatively affected by variable weather conditions. Physical as well as economic and social access to food would be impacted by climate change as agricultural production declines, food prices increase and purchasing power decreases. Climate change is equally a threat to food utilization through its direct effects on human health and the spread of diseases in geographical areas which were previously not affected. Current responses to climate change threats, particularly those affecting agriculture in developing countries and hence, the majority of the rural poor underestimate the gravity of the situation.

2.2 The Politics of Climate Change

Climate change has become a political issue at both global and regional levels with two divergent views emerging. There is a school of thought that believes climate change does not exist but rather the impacts being felt are climate variability and not climate change. This school of thought is common in the United States of America (USA) and is propagated by people like Jim Inhofe, the Koch brothers, donors, oil companies and politicians like Al Gore. The other world view propagates that the earth's climate system has changed resulting into increased and severe occurrence of disasters and the major proponents include world renown scientists like Professor Bolin , Hogbom, Arrhenius and Keeling (Bolin, 2007). This study therefore, takes the view that both climate change and climate variability exist and has negative consequences on agriculture and household food security. There is, however, enough evidence that climate change is real and that the global mean temperature has increased between 0.3°C and 0.6°C since the late nineteenth century (Bolin, 2007).

2.3 The Evolution of the Concept of Food Security

The concept of food security has evolved over the last three decades and started emerging in the 1970s during the deliberations on international food crisis at a time of global food crisis. The primary concern of these discussions was mainly on food availability and price stability of basic foodstuffs to some extent. During the World Food Summit in 1970, food security was defined as availability at all times of adequate world food supplies of basic food stuffs to sustain a steady expansion of food consumption and to offset instability in production and prices (Ulrich, 2011).

In an attempt to broaden this definition, the Food Agriculture Organization (FAO) in 1983 included securing access by vulnerable people to available supplies. In 1986, the World Bank advanced the definition of food security by distinguishing between chronic food insecurity associated with problems of continuing structural poverty and transitory food insecurity which was a product of natural disasters and economic collapse (FAO, 1912). This definition was further broadened to include access of all people at all times to enough food for an active and healthy life. By 1990, the World Food Summit adopted a still more complex definition, which contained that "food security, at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2012).

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life, (FAO, 2003). National food security refers to the situation where each person and member of any household has physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept at household level, with individuals within households as the focus of concern. Hence, adverse weather conditions such drought and floods, political instability (social unrest) or economic factors (unemployment, rising food prices) may impact on household food security status. With climate change, the yields of some major crops like maize, groundnuts and wheat are likely to be reduced, for example, decrease of 6.9 percent for maize by 2020 as compared to the drought resistant crops like sorghum, millet and cassava (Brown and Crawford, 2007). The decreases in crop yield and livestock production will make the majority of the rural poor to be food insecure.

The impacts of climate change on food availability will be experienced differently, depending on location. For example, moderate warming (increases of 1ºC to 3ºC) is expected to benefit crop and pasture yields in temperate regions, while in African tropical and seasonally dry regions, it is likely to have negative impacts, particularly for cereal crops. Warming of more than 3ºC is expected to have negative effects on production in all regions (IPCC, 2007). It is projected that climate change and climate variability is likely to have a negative bearing on agricultural

production which will in turn compromise household food security. The supply of meat and other livestock products will be influenced by crop production trends, as feed crops account for roughly 25 percent of the world's cropland (Eugene, 2013).

2.4 Climate Change, Agriculture and Food Security: Global Perspective

Climate change, agriculture and food security has become a major subject of global concern because impacts of climate change cut across the globe irrespective of boundaries. Climate change has emerged over the last 25 years not just as a physical reality, affecting global and regional climates, but also as a socio-cultural phenomenon, an icon of a globalizing world which is increasingly altering the physical fabric of the planet and at the same time demanding new forms of global governance (Hulme and Turnpenny 2004). However, the increased frequency of extreme and unpredictable weather events, in a manner consistent with the changes predicted by global climate models is expected to exacerbate the global food challenge as the world moves toward the middle of the 21st century (Eugene, 2013). Mudenda *et al.* (2009), notes that climate change is likely to impact on agriculture and food security across the globe. Any impacts on agriculture will have multiple effects on agriculture dependent livelihoods and household food security.

The concept of food security goes far beyond production and encompasses issues relating to availability of food, distribution, access, utilization and exchange aspects. Food security is dependent on availability of food, access to food, utilization to food and stability. Edame argues that climate change will affect the four key dimensions of food security and these are availability, stability, access and utilization (Edame, 2013). The United Kingdom (UK) experienced the adverse effects of climate change during the 1995 drought and the autumn flooding in 2000 which affected agricultural productivity and household food security (Hulme and Turnpenny, 2004). It was at that time that climate change related issues attracted the attention of society and political leaders in the UK which culminated into the publication of the first Comprehensive Climate Change Programme identifying climate change related risks as well as policy measures and initiatives which would help in managing climate change risks. The comparable figures for Southern Asia, the region with the second highest undernourishment rates, were 24 percent and 21 percent respectively. Moreover, the latest figures for fragile countries show a rate of undernourishment of 31.4 percent compared to 14.5 percent for non-fragile countries due to low

agricultural production and food insecurity arising from impacts of climate change (FAO, 2012).

The USA in the Midwestern of the states experienced high daily minimum temperatures from 2010- 2012 rainy season affecting crop yields (Peters *et al*., 1971; Hamlin, 2012). However, this study does not state to what extent yield loss affected the four pillars of food security in the affected areas (Eugene, 2013). Arising from this argument it is clear that the impacts of climate change on agriculture and household food security will vary from region to region. The Western US, particularly the US Southwest, is projected to be impacted by climate change much more than the Eastern half (Kurukulasuriya and Mendelsohn, 2006). Although there has been a lot of studies on the impacts of climate on agriculture, most of these studies have been biased towards the scientific aspect at global level.

Climate change is a major challenge for agriculture, food security and rural livelihoods for more than 60 percent of the population in the Asia-Pacific region (Edame *et al*., 2011). Consistent warming trends, more frequent and intense extreme weather events such as droughts, cyclones, floods, and hailstorms have been observed across Asia and the Pacific in recent decades. Rice producers in Eastern India and the Terai of Nepal suffer from frequent droughts; Bangladesh, Bihar and Assam (States in India) suffer yield losses from frequent floods and submergence; and the wheat farmers in North-West Frontier Province (NWFP) of Pakistan face similar challenges to many parts of Afghanistan (Lal *et al*., 2011). In South Asia, over 40 percent of under-five children are under-nourished and in many areas, under-nutrition rates are as high as those in the poorest African countries such Somalia and Chad.

2.5 Impacts of Climate Change on Agriculture and Food Security in Africa

Climate change, agriculture and food security are very broad concepts which have attracted the attention of many researchers in the last three decades. Climate change, agriculture and food security is increasingly becoming a subject of great concern both in developed and developing countries alike. There is unanimity among most researchers that climate change effects are being felt across the globe. Majority of the people (85 percent) in rural Africa depend on agriculture for their survival and household food security. The African continent has become warmer than it was 100 years ago, warming at the rate of about 0.5°C in this century and temperature is likely to further increase between 1.5°C to 4°C Centuries to come (Hulme *et al.*, 2005 and FAO, 2009). Substantial Inter- annual and multi-decadal variations have been observed and near continent-

wide droughts in 1983 and 1984 had dramatic impacts on agricultural production and food security (Benson and Clay, 1998).

Although climate change will have both positive and negative impacts on rural economies and livelihoods, predominantly negative effects are expected in developing countries (Richard *et al*., 2007). This is a clear indication that the impacts of climate change are both positive and negative, however, most studies tend to ignore the positive impacts of climate change. It is widely agreed among researchers that El Nino Southern Oscillation (ENSO) is the significant source of inter-annual climate variability in the tropics (Assessments of Impacts and Adaptation to Climate Change, 2007). However, the IPCC (2014) notes that climatic changes in precipitation and global warming will cause the sea level to rise. Christensen *et al.* (2007), observes that an increase in the intensity of high rainfall events is expected in Africa as in other regions affecting the vulnerable communities living along coastal areas. In the same vein, some models also project more frequent and severe drought periods in many parts of Africa (Christensen *et al.,* 2007). A number of countries like Mozambique, Ivory Coast and Kenya along coastal areas have been adversely affected by sea level rise. Due to sea level rise, coastal areas have been flooded thus destroying crops, infrastructure and ecosystems. This leads to low agricultural productivity hence causing food insecurity. The poor in developing countries are more vulnerable compared to the rich with high adaptive capacity in developed countries.

The most significant impacts of climate change in many African countries arise from higher temperatures changes ranging between 3°C and 4°C, increased water scarcity and extreme weather events such as floods and droughts that will most strongly affect agriculture which will cause animal stress and crop failure. It is therefore, safe to assume that temperature changes across countries like Mali, Zambia, Tanzania and Malawi will follow the general trend for the whole Africa. The overall effects are likely to be stronger if global warning exceeds 2°C (Lobell *et al*., 2011).

Global temperature has been rising over the last decade and this can be traced to the melting of mountain glaciers. The ice on top of Mount Kilimanjaro is already melting due to rise in global temperature (Lobell *et al*., 2011). The melting of mountain glaciers, ice margin and thermal expansion of the oceans West of Greenland during the last century shows that the major part of

sea level rise is linked to global warming (Bolin, 2007). Agriculture in Africa is rain fed, therefore any fluctuations in water availability and temperature will result in reduced crop yield and livestock losses. The impacts of climate change on agriculture and food security are going to make it difficult to achieve food security due to increased commodity prices and reduced crop production at both global and regional levels. Crop yields are projected to decline by 50 percent while revenue from crop sales is forecast to decrease by as much as 90 percent in the coming decades and agriculture losses of between 2-7 percent of GDP is expected in parts of the Sahara, 2-4 percent in West Africa and 0.4-1.3 percent in Central Africa (FAO, 2009). The World Bank (2008), projects that Sub-Saharan Africa will become the most food insecure region compared to Asia with almost 45 percent of the population being undernourished in 2080 compared with 24 percent currently. On the positive side, countries like Ethiopia may have long growing periods due to climate change (World Bank, 2008).

The world's resources are adequate to produce enough food for its population for at least the next few decades. However, due to uneven distribution of food, many countries experience food insecurity, with food supplies inadequate to maintain their citizens' per capita consumption or to meet their nutritional requirements, (Shapouri and Rosen, 2001). Although there are food security challenges across the world, most progress remains to be made in Africa and in countries in fragile situations. According to Kandji *et al.*(2006), the proportion of undernourished population in Sub-Saharan Africa, decreased from 32 percent (1990-1992) to 29 percent in 2008. Extreme rainfall and subsequent heavy flooding damage will also have serious effects on agriculture including the erosion of topsoil, inundation of previously arid soils, and leaching nutrients from the soil (World Wide Fund for Nature, 2006). From 1996 to 2003, as observed by Funk *et al.* (2005), there has been a decline in rainfall from 50-150 mm per season and corresponding decline in long-cycle crops such as slowly maturing varieties of sorghum and maize across most of eastern Africa. Long-cycle crops depend upon rain during this typically wet season and progressive moisture deficit results in low crop yields in the fall, thereby impacting the available food supply.

2.6 Climate Change, Agriculture and Food Security in Sub- Saharan Africa

According to Thornton (2012), agriculture is the economic mainstay of many Sub- Saharan countries, employing about 60 percent of workforce and contributing an average of 30 percent of

GDP. Climate change is considered as posing the greatest threat to agriculture production and food security in many Sub- Saharan Africa countries due to low adaptive capacity to effectively cope with falling crop yields among others. Southern Africa, in particular, already experiences climate variability, in the form of droughts and floods, and this is projected to intensify in the future. This will have negative implications for agricultural productivity by changing the nature of the growing season and the spatial area suitable for different crop types. Though food security is not solely dependent on food availability, changes in productivity are likely to have implications on the food security of vulnerable groups of the population (Vincent and Cull, 2014). At regional level a warming of 1°C to 2°C is expected to result in decrease in agricultural yields in arid, semi- arid and tropical regions. Further, for example in the Sahel region, Agro-ecological zones are likely to shift in ways difficult to predict. Countries such as Zambia, Zimbabwe, Mozambique, Namibia, Botswana, Lesotho and South Africa have experienced more droughts (1986/1987, 1991/1992, 1994/1995 and 2001/2003) compared to floods (1986/1987 and 1997/1998). For example, in the last 30 years Zambia, Zimbabwe and Mozambique have experienced four drought and two flood events (Dev and Sharma, 2010).

Thornton *et al.* (2012) Food insecurity is one of the greatest challenges facing Sub-Saharan Africa and this is attributed to frequent occurrence of extreme weather events such droughts and floods, low investments in the agricultural sector, low agricultural productivity, high transportation cost, poor infrastructure, inadequate markets and weak financial support systems for farmers (Timothy *et al*., 2009). Countries in Sub-Saharan Africa such as Zambia, Zimbabwe, Mozambique, Democratic Republic of Congo and Tanzania are vulnerable to frequent extreme weather events such as droughts and floods which affect agricultural productivity and food insecurity. According to Parry *et al*. (2004), food production and prices are being hit globally by extreme climate events such as floods and droughts. The Horn of Africa experienced severe drought in 2011 due to climate change impacts which caused food insecurity (Atieno, 2011). According to Elagib and Elhag (2011), about 11 million people were in need of food assistance in the Horn of Africa in 2011, 4 million people suffered from acute food crisis in Somalia and 3.7 million in Kenya were food insecure. Although countries in the temperate region are likely to generally enjoy increased agricultural productivity, countries in the tropical and sub-tropical regions are likely to suffer agricultural losses due to climate change which is most likely to affect food availability negatively in the coming years (Dev and Sharma, 2010).

The effects of climate change are evident in Zimbabwe's increasing variability in rainfall patterns, high temperatures (26°C and above), increased frequency and extremity of droughts and floods. Despite other factors that have affected Zimbabwe's agricultural sector such as the agrarian land reforms, climate change has played a major role in destabilizing food production in the country. During the 2011/ 2012 season, Zimbabwe was forced to import over 50 percent of its maize requirements (Timothy *et al*., 2009). This has mainly been attributed to a reduction in the amount of rainfall received annually which has greatly affected yields of the maize crop. The February 2000 flood in Mozambique resulted into 700 deaths, U$ 500 million economic loses and 4.5 million people were affected by food insecurity among other impacts (Adesina *et al*., 1999).

2.7 Impacts of Climate Change on Agricultural Production in Zambia

The GHGs Emissions in Zambia in 1994 stood at 51.52 million tons CO_2 equivalent and 54.72 million tons in 2000 and are expected to further rise to 216.8 million tons CO_2 equivalent by 2030. However, there are strong indications that GHGs have increased by 6.2 percent from 1994 to 2000. Land use change and forestry accounted for the largest contribution, 73.7 percent followed by agriculture at 18.9 percent, emissions from the energy sector accounted for 4.8 percent, and industrial processes stood at 1.8 percent and contributions from waste was 0.8 percent (IPCC, 2007). The major contributing factor to GHG emissions in Zambia is deforestation and mining activities. In Zambia, agriculture continues to be an important source of household food security and livelihood, supporting about 85 percent of the population. The country's agriculture sector is dominated by small scale rural farmers who are dependent on rain for crop production (Mikkel *et al.,* 2013).

The Ministry of Tourism, Environment and Natural Resources (MTENR) reveals that 85 percent of the population participates in agriculture and the sector contributes 20 percent to GDP (MTENR, 2011). Climate change is expected to exacerbate the effects of floods and droughts because of the predicted increase in frequency and severity of climate hazards. This will increase the vulnerabilities of many sectors, livelihoods and assets within Zambia. The expected impacts of climate change include an increase in the mean annual temperature of 1.2°C to 3.4°C by 2060, a decrease in rainfall during the months of September to November period and an increase during December to April (Nehemia *et al*., 2009). These changes are predicted to result in seasonal

droughts, dry periods within the rainy season, intense rainfall, heat waves, increased temperatures in valleys, floods, flash floods and changes in growing seasons as a result of delayed onset of rainy season or shortened growing period. Thus, any abrupt change in climate has a potential to significantly reduce agricultural production and household food security. Since the majority of Zambia's population lives in rural areas and depend heavily on rain-fed agriculture for food and income, climate change presents a challenge to the country's attempts to reduce rural poverty, which currently stands at 80 percent (CSO, 2010).

According to Thurlow *et al*. (2009), there is a 75 to 80 percent chance in any given year that there will be either a drought or a flood in these three zones (droughts affected Agro-ecological region I, four in region IIa, and one in Zone IIb). Therefore, an increase in the frequency and severity of El Niño events has been observed from the 1980s for example strong El Niños occurred every 10 to 20 years. Further, between 1988 and 1992, more than 15 El Niño drought events were reported at regional and national levels (Kandji *et al*., 2006). The vulnerability of crop production to climate shocks in Zambia is further enhanced by the fact that a significant of arable land in Zambia is in a semi-arid region of Central, Eastern and Southern Provinces.

Impacts of climate change in Zambia are closely associated with droughts and floods which lead to loss of life, livestock and human diseases, destruction of agricultural crops resulting in food shortages, displacement of populations, damages on infrastructure such as roads, schools, health facilities and water points like boreholes. These impacts of drought are well pronounced in drought sensitive areas of agro-ecological region I in Southern Province. The drought conditions of 1991/1992, 1994/1995, and 2004/2005 led to a near complete or complete crop failure in several areas of Southern Province with an average reduction in crop yields of 65- 72 percent (Thurlow *et al*., 2009). The occurrence of extreme events like floods and droughts shows in increasing trend for all the provinces with Southern Province being the most affected as indicated in Table 1. For example, Table 1 shows that in the last 13 years, 835,130 households were affected by both floods and droughts compared to the Copperbelt province which had 23,582 affected households and Luapula Province had 30,554 affected households (ZVAC, 2016).

Table 1: Impacts of Extreme Events from 2003 to 2016

YEAR	2003	2005	2007	2008	2009	2010	2012	2013	2014	2015	2016	TOTAL NUMBER OF AFFECTED HOUSEHOLDS
EVENT	DROUGHT	DROUGHT	FLOODS	FLOODS	FLOODS	FLOODS	FLOODS/ DRY SPELLS	DRY SPELLS	FLOODS	DRY SPELLS	DRY SPELLS	
CENTRAL	-	277,632	-	32,232	18,174	3,258	-	53,637	-	4,573	12,063	401,569
COPPERBELT	-	-	-	23,582	-		-	-	-	-	-	23,582
EASTERN	10,349	118,643	-	32,352	-	9,800	10,661	-	26,461	60,498	32,498	301,262
LUSAKA	2,655	49,677	-	211,066	-	3,753	-	19,016	-	-	8,967	295,134
LUAPULA	-	-	-	9,024	-	-	-	18,094	3,436	-	-	30,554
SOUTHERN	46,935	429,132	-	130,086	-	19,024	47,097	87,490	-	-	75,366	835,130
NORTH WESTERN	-	23,774	71,548	14,490	67,115	2,445	5,084	-	748	5,249	-	190,453
NORTHERN/ MUCHINGA	-	-	244,715	74,028	25,361	-	-	16,071	6,128	-	-	366,303
WESTERN	-	333,804	124,603	96,592	-	34,459	-	15,188	18,252	29,805	42,732	695,435
TOTAL	**61,942**	**1,234,667**	**442,873**	**625,460**	**112,659**	**74,749**	**64,854**	**211,509**	**57,039**	**102,140**	**173,642**	**3,139,422**

Source: Adapted from the Zambia Vulnerability Assessment Reports, 2003- 2016

2.8 Household Food Security

Achieving food security requires adequate food availability, access and absorption. Agriculture plays a vital role in contributing to all the three components of food security (Dev, 2011). The definition of food security by Dev (2011) fails to take into consideration nutrition which is an important pillar for food security as defined by the FAO. The FAO defines food security as 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" (FAO, 2003). According to FAO (2009), there are four key dimensions of food security which are food availability, food accessibility, food utilization and food system stability or affordability. Increasing temperatures and shifting rain patterns across Zambia will reduce access to food and create effects that impact regions, farming systems, households and individuals in varying ways.

2.8.1 Food Availability

Both more extreme weather and slow-onset changes in the climate (increasing temperatures and changing rainfall) will hit food production and food distribution systems, reducing the amount, type and quality of food available for consumption (Kurukulasuriya and Mendelsohn, 2006). Food availability addresses the "supply side" of food security and is determined by food production levels, stock levels and net trade. The availability of sufficient food within a country is not an indicator of household food security (Doken and White, 2001). For example, Zambia has continued to record a bumper harvest in the last five years but this has not translated in improvements of food security of all people in many parts of the country at household level.

2.8.2 Food Access

Household food access is the ability to acquire sufficient quality and quantities of food to meet all household members' nutritional requirements. Climate change will significantly increase the risk of hunger and malnutrition. This argument was also echoed by Doken and White (2001) that the problem of under nourishment is often linked to the lack of access to food and poor distribution. Sufficient access to food may be determined by adequate incomes or other resources to purchase levels of appropriate foods needed to maintain consumption of an adequate diet/nutrition level (Parry *et al*., 2004). This means that access to food is determined by physical and financial resources, as well as by social, cultural and political factors. Edame (2013), insulates this debate by arguing that markets and non-market mechanisms are the two determinants of food accessibility.

2.8.3 Food utilization

Consumption and nutrition are the two key dimensions of food utilization, Nyanga (2012) with the former referring to food quantity and quality of dietary needs while the latter relates to the extent to which the body is able to make use of nutrients from the consumed food in order to live an active and healthy life (Riely *et al*., 1999). The rich can adapt to climatic shocks through private insurance and selling off assets or by drawing on their savings yet the poor may have no or very low adaptive capacity thus reduce consumption and cut nutrition levels hence making them more food insecure.

2.8.4 Food System Stability

To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (for example an economic or climatic crisis) or cyclical events (seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security (Glantz, 1994). Most studies fail to distinguish between impacts of climate change and chronic food insecurity. Most of the studies tend to focus on crops such as maize and do not take into accounts local foods such as caterpillars and local fruits or wild fruits to buffer against food insecurity. The effects of climate change on livestock and fisheries on which the majority of the poor in rural areas depend on are also overlooked.

Adaptation of agricultural systems and food security to climate change remains a critical component for achieving household food security and agricultural growth. Climate change will affect already declining fish stocks due to increased temperatures, water scarcity or declining water levels in water bodies and disease outbreak which will have a negative bearing on household food security in rural areas. For example, spotted tilapia, (*Tilapia Marie*), which is common in parts of Africa, prefer temperatures between 25°C and 33°C, depending upon acclimation temperature, and have critical thermal maxima of 37°C (World Wide Fund for Nature, 2006).

2.9 Climate Change Impacts on Agricultural Production and Food Security in Kazungula

Climate change and climate variability can affect agricultural production through their impact on temperature changes and water availability. Climate change and climate variability is one of the main sources of uncertainty and risk in agricultural systems in Kazungula district due to its dependence on weather and most production decisions directly or indirectly involve weather factors (Hulme *et al*., 2005). The FAO report indicates that increased frequency and intensity of flooding and drought will have negative impacts on agricultural production, particularly food security (FAO, 2009). For instance, for maize to grow it needs average rainfall of 450 to 600 mm of water per season and an average temperature of 20°C (Eriksen, 2005). The critical temperature detrimental to the growing of crops such as maize in the tropics is approximately 32°C.

Historically, Kazungula has been experiencing a combination of extreme weather events such

droughts, floods and extreme temperatures. According to Glantz (1994), meteorological drought refers to lack of rainfall compared to an expected amount over a certain time period while agricultural drought is the insufficient rainfall to support agricultural activities prevalent in the area. Kazungula district displays considerable climatic variability. Rainfall records for nearby stations obtained from the Zambia Meteorological Department (ZMD) and satellite images from different Regional Climate Models provides evidence that the climate system has changed in Kazungula district further countering those that argue that the climate has always been changing due natural factors (Eriksen 2005 and Bolin 2007). Therefore, Figure 1 below is twofold; historical data from the ZMD shows that temperature has increased by 2°C and the ensemble of different regional models show that there is climate variability in Kazungula district.

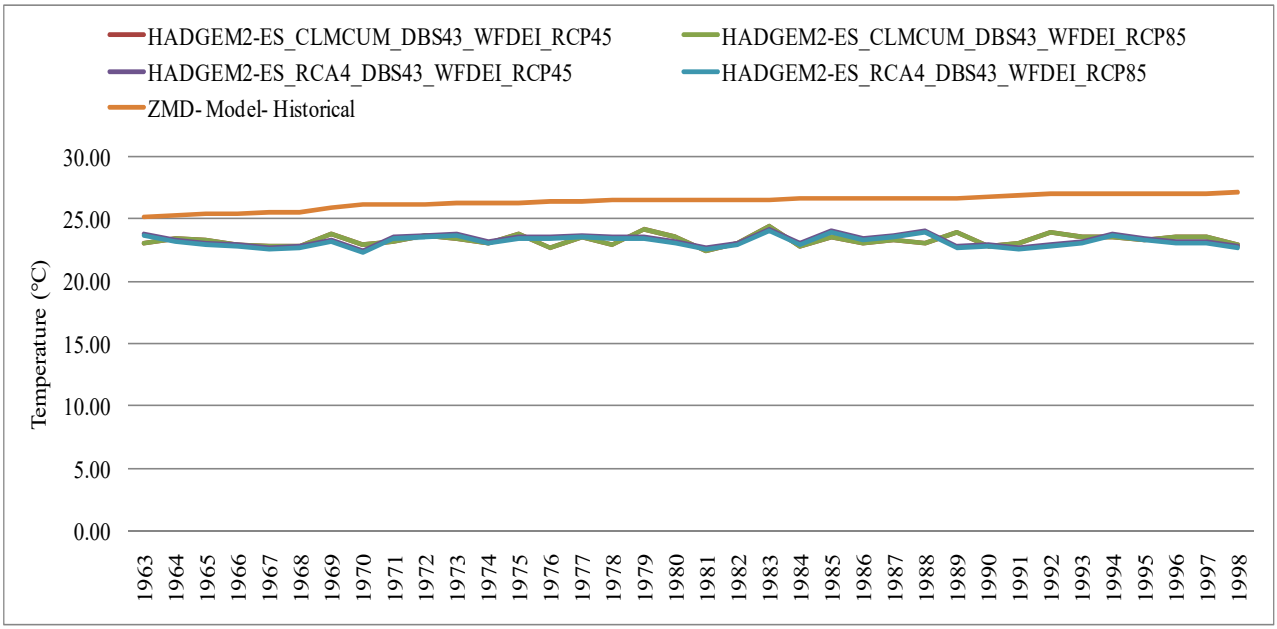

Figure 1: Climate change and climate variability trends from 1963-1998

Source: Adapted from the Coordinated Regional Climate Downscaling Experiment (CORDEX, 2016)

Previous studies recount that agriculture and household food security in Kazungula has failed for a number of reasons in the past due to climatic (insufficient or excessive quantity or unsuitable distribution of rainfall), animal diseases and pest infestation. This research therefore, focuses on the hydro- meteorological hazards that have occurred in the last 35 years and their implication on agriculture production and household food security. There is overwhelming evidence and

literature augmenting that the local climate in Kazungula has changed in the last 35 years hence impacting negatively on agricultural production and household food security. Like any part of Zambia, the district is highly vulnerable to the impacts of climate change and variability due to high illiteracy levels, high poverty levels and lack of local capacity to cope with the adverse impacts of climate change and variability. A study modeled the impacts of climate change on agricultural production and demonstrated that crop yields are likely to decrease over the next century due to climate change.

Climate change and variability has contributed significantly to crop failure and food insecurity due to frequency and increased severity of droughts, dry spells and floods in Kazungula (Funder, 2013). The affected crops include maize, beans, groundnuts and sweet potatoes. In order to cope with the adverse effects of climate change and variability, Kazungula needs to come up with coping strategies such as the promotion of conservation agriculture, growing of drought resistant crops like cassava and sorghum and looking for alternative sources of livelihoods. Kazungula district has been selected for this study because of the recurrent occurrence of floods since 2005/ 2006, 2006/2007 and the droughts of 2007/ 008 (ZVAC, 2008).

CHAPTER 3

DESCRIPTION OF THE STUDY AREA

3.1 Location

Southern Province has 14 districts and covers an area of 85,500 km^2 and is bordered by the Zambezi River to the South, the Kariba reservoir to the east and the Kafue River to the north. Kazungula district lies within the Zambezi valley in Southern Province. Kazungula district is geographically located between longitude 24° 56' to 26° 32' and latitude 16° 8' to 18° 0' South of the equator in Agro- ecological region 1 as shown in Figure 2 (Swennenhuis, 2012).

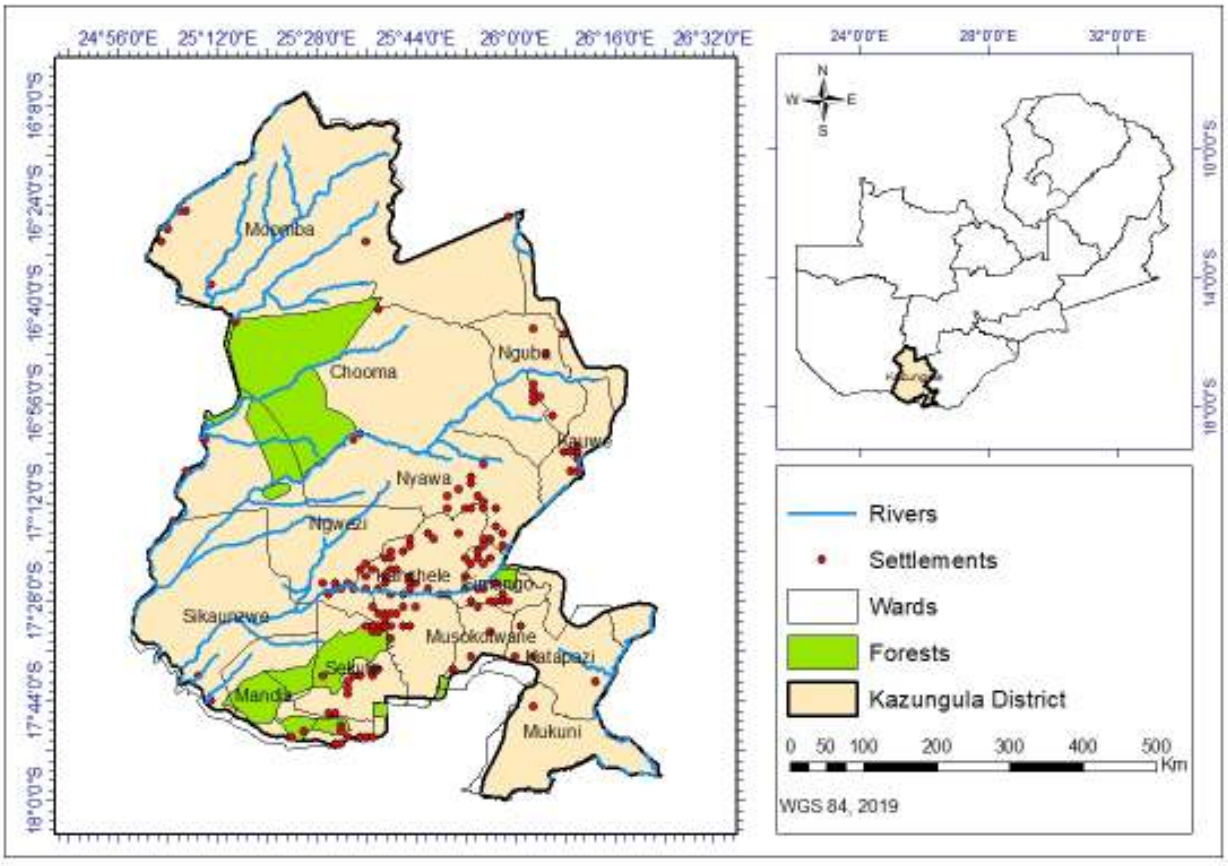

Figure 2: Location of the study Area, Kazungula District

Source: Field Survey, 2016

3.2 Population Size

According to CSO (2012), Zambia's population as of 2010 was 13,046,508 of which 7,978,274 people (61 percent) reside in rural areas. Therefore, the population of Kazungula district has

increased from 34,133 in 2000 to 53,117 in 2010. Kazungula district has a total population of 104,731 translating into 20,024 households (CSO, 2012).

3.3 Climate

Kazungula's geographical location and topography gives the districts what may be described as a sub-tropical climate with three distinct seasons: the hot-dry season from mid- August to November (26^{o}C - 38^{o}C); the rainy season from November to April (27^{o}C - 34^{o}C) and the cool dry season from April to mid-August (13^{o}C - 26^{o}C). Although, annual rainfall in Zambia ranges from 600 mm - 1100 mm/year and follows a north-south gradient, with an average of 700 mm/year in the south and 1,400 mm/year in the north. Kazungula district lies in Agro- ecological region I which receives between 600mm to 800mm annual rainfall and is generally considered the driest and most prone to drought occurrences (Swennenhuis, 2012).

Rainfall in Kazungula is also strongly influenced by the El Niño Southern Oscillation (ENSO), which brings drier than average conditions in the wet summer months. The reverse occurs during La Niña episodes, with dry conditions been experienced in the district. The influence of ENSO contributes to uncertainty in climate projections for this region. The rainy season is also affected by the Inter-Tropical Conversion Zone (ITCZ) which oscillates between the northern and southern tropics over the course of a year. Variability in the movement of the ITCZ leads to variability in rainfall performance during the year.

The mean monthly temperatures during the months of October/ November are hot (22.5^{o}C - 26°C). The cold season is mild with mean monthly temperatures between 13.5^{o}C and 16.5°C. Daily minimum temperatures during this season often fall below 10°C. Due to the continental position of the district and the predominately high altitude, the temperature shows a large daily range. Due to its lower altitude, the Kazungula experiences the highest temperatures exceeding 26°C during the hot season.

3.4 Soils

The dominant soil types in Kazungula district are classified as acrisol, luvisol, lithosol and arenosol. The Karoo sand, silt and mudstones in the Zambezi Valley are overlain by the more fertile luvisols and cambisols. The Kalahari sands are mainly covered by arenosols. These sandy-

textured soils are often highly permeable and lacks a significant soil profile development (Swennenhuis, 2012). Soils in Kazungula district are generally poor for agriculture except for areas along the Zambezi river and its tributaries.

3.5 Vegetation

Most of the areas in Kazungula are classified as miombo woodlands which is highly dominated by semi-evergreen trees 15 meters to 21 meters high with a well-developed grass layer. Along the escarpment zone and within the Zambezi Valley, mopane woodland is the predominant vegetation type. This is one-storeyed woodland with an open canopy of 6 meters to 18 meters in height. Next to mopane woodland, scattered elements of munga woodland dominated by various species of acacia, dry forests, grassland and open woodland can be found in Kazungula district (Swennenhuis, 2012).

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

This research utilized both qualitative and quantitative methods of data collection. This research utilized the quantitative approach by developing structured questionnaires, observations and collection of historical data. Qualitative methods were employed to collect data from Focus Group Discussions.

4.2 Data Collection

In order to determine and analyze the impacts of climate change on agriculture and household food security, primary data was collected through a survey of farmers in Kazungula district of Southern Province. The data was collected using three sets of questionnaires and these were administered to individual respondents (household questionnaires), key informants at the district level (district questionnaire), key institutions and informants at community level (community questionnaires for focus group discussions).

A quantitative assessment of climatic effects was based on agricultural production which was partially determined by crop yields over a period of time. This research therefore, analyzed both temperature and precipitation as key variables of climate change and variability in determining agriculture production and food security. Historical agricultural data and climate data was collected from the Ministry of Agriculture, Zambia Meteorological Department and Regional Climate Models (RCMs) using the Coordinated Regional Climate Downscaling Experiment (CORDEX) from the Swedish Hydrological and Meteorological Services respectively. Food security was determined by the data that was generated through the field survey in Kazungula district.

4.2.1 Primary Sources of Data

Primary data was obtained through engagements with individuals from institutions that directly interface with climate change related issues in the country and was purposively selected using non- probability sampling techniques. This data was collected through administering of structured questionnaires at household level, interviews with district officials and traditional

leaders as well as Focus Group Discussions with members of the community. The household questionnaire was administered to the communities at household level (Appendix I), community questionnaire was administered to four communities through Focus Group discussions (Appendix II) and the key informant questionnaire was administered to the District Administration and other key informants who deal with climate change related activities in Zambia at different levels (Appendix III).

4.2.2 Secondary Sources of Data

Secondary sources of data were obtained from published sources (journals, articles and edited books). Furthermore, the research involved visiting key institutions both government and Non-Governmental Organizations to collect data on climate change and agriculture statistics. This data was vital in filling the gaps from field responses. Visited institutions included Ministry of Lands, Environment and Natural Resources Management, Pilot Programme for Climate Resilience, Zambia Meteorological Department, Swedish Meteorological and Hydrological Services, Ministry of Agriculture and World Food Programme.

4.3 Sampling design

Sample designs may be categorized into two different categories that are probability sampling and non- probability sampling in order to have a representative sample. Probability sampling which is also known as random sampling ensures that elements in the population have equal chance of being selected. Under non- probability sampling the elements of the population are deliberately chosen by the researcher. This research used non- probability sampling in selecting the wards to be visited, institutions and focus group discussions because the universe was too small. The research further used simple random probability sampling to select households that were interviewed to ensure that the elements in the population had equal chance of been selected to keep the sampling error low.

According to CSO (2010), Kazungula district has 11 wards with a total number of 10,132 households. A register of famers with a total of 656 households was obtained from the District Agricultural Office from which the sample was drawn. This research used Krejcie and Morgan Sampling Method to obtain the sample size in order to avoid biasness (Bryman, 2008). The sampling of households was carried out using the sampling frame from Central Statistical Office

at the Standard Enumeration Area (SEA). This research used probability random sampling following Krejcie and Morgan which is one of the commonly employed sampling method in research. Krejcie and Morgan, 1970 used the following formula to determine the sample size:

S= required sample size

$$S = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

X^2= the table value of chi-square for one degree of freedom at the desired confidence level
N = the population size
P = the population proportion (assumed to be .50 since this would provide the maximum sample size)
d = the degree of accuracy expressed as a proportion (.05)

Therefore, the total sample size for this research using Krejcie and Morgan (1970) was 242 households which were interviewed during the research period. However, the selection of the sample size was done using simple random probability sampling as demonstrated below while the sampling of institutions utilized non-probability sampling methods. This means that this research utilized both probability and non-probability sampling methods. The household sample size for this research was derived as illustrated below:

$$S = \frac{3.841 * 656 * 0.50(1-0.50)}{0.05^2(656-1) + 3.841 * 0.50(1-0.50)}$$

$$S = \frac{3.841 * 656 * 0.50(1-0.50)}{0.05^2(656-1) + 3.841 * 0.50(1-0.50)}$$

$$S = \frac{3.841 * 656 * 0.50(0.5)}{0.0025(655) + 3.841 * 0.50(0.5)}$$

$$S = \frac{629.92}{1.6375 + 0.96025}$$

$$S = \frac{629.92}{2.59775}$$

S= 242.486

Sample Size= 242

The formula for the sampling procedure at household level was as follows:

$$\text{K or I} = \text{N}/\text{n}$$

Where K or I = Sampling Interval

N = Total Number of Households assigned sampling serial number

N = Sample Size

K or I= 656/ 242

Kor I = 2.7107438

Kor I = 3

Sampling Interval = 3

After the sampling interval (K or I) had been calculated then the Random Start number was picked randomly from the Random Start Table and the sampling was cyclic. Therefore, the formula and sampling of households at community level was done as follows:

RS+ K or I

Where RS= Random Start

K or I = Sampling Interval

Therefore,

RS or First Respondent

RS+ K or I

RS+ K or I+ K or I

RS+ K or I K or +I K or +I

RS= 662

662+ 3= 665

$$662 + 3 + 3 = 668$$

$$662 + 3 + 3 + 3 = 671$$

To achieve this, a quick count was undertaken in four Supervisory Enumeration Areas (SEAs) and all the households were listed using a listing form.

4.4 Data Analysis

After the completion of data collection exercise, the data was edited or cleaned, coded and entered into Census and Survey Processing System (CSPro). After the data was entered into CSPro, data analysis was undertaken using Statistical Package for Social Sciences (SPSS) and excel. The study examined the nature and typology of climate change induce hazards affecting agricultural production in Kazungula district. This was undertaken by analyzing people's perception on the types of hazards affecting them. The study, further examined historical data from the Zambia Meteorological Department and the Regional Climate Model data from CORDEX to validate the people's perception. The study also analyzed the impact of climate change and climate variability on agricultural production and the adaptive capacity of rural households to cope with the adverse effects of climate change and climate variability. Further, the study also analyzed the impacts of climate change on the four pillars of food security (access, utilization, availability and food stability) as well as nutritional security. For nutritional security, the study analyzed the nutritional status of the under five children as a proxy for measuring food utilization.

4.5 Limitations of the Study

The major limitation to this study was inadequate meteorological data (both current and projected) at local scale on impacts of climate change in Zambia both on crop yields and on poverty levels at a level that is useful to both policy makers and researchers. Most of the datasets were at global and regional level rather than community level; hence lack of local meteorological and agricultural datasets was a big challenge. Kazungula district does not have a meteorological station hence the meteorological data that was used in this research was interpolated from Livingstone weather station.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

This chapter, in view of the above, presents the results of the survey on the impacts of climate change and climate variability on agricultural production and household food security in Kazungula district of Southern Province. This chapter, further discusses the population characteristics of the respondents, nature of climate change affecting households and impacts of climate change on agriculture and household food security as well as the coping strategies being employed by the people.

5.2 Population Characteristics

The research showed that most of the households interviewed were male headed (77 percent) while 23 percent were female headed households. The research further showed that (Figure 3) most of the households are headed by different age groups with the majority of the households (35 percent) being headed by people aged between 35- 44 years followed by people aged between 25- 34 years (24 percent) 45- 64 years (16 percent) while 14 percent were headed by the elderly aged above 65 years (Figure 3). This shows that both male and female headed households were exposed to the adverse impacts of climate change and climate variability. However, the impacts of climate change will be severely felt by women than male headed households as well as child and elderly headed households due to low coping capacity. These are the age groups that will most likely be affected by food insecurity.

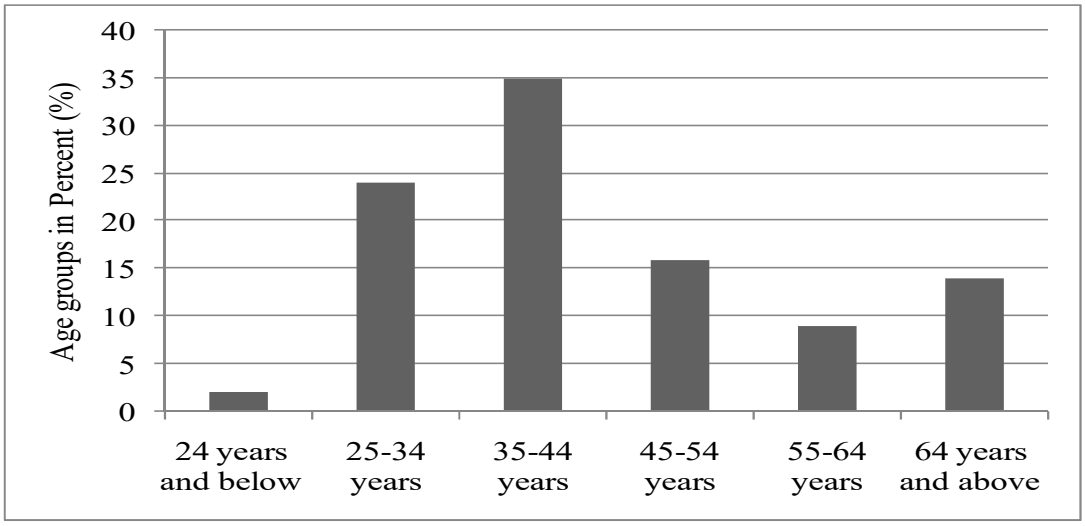

Figure 3: Age of Household Heads

Source: Field data, 2016

In terms of education levels attained by household heads, the research showed that majority of the people had only reached primary education (63 percent) followed by 21 percent of the population that had attained secondary education while 11 percent had gone as far as tertiary education and 5 percent had never been to school (Figure 4). This finding showed that literacy levels in the district were very low which has implications on nutrition security. The more educated the population is the less vulnerable it is to the adverse impacts of climate change and climate variability. The high illiteracy levels in the district equally affect people's understanding of climate issues and on how to respond to the adverse effects of climate change and climate variability.

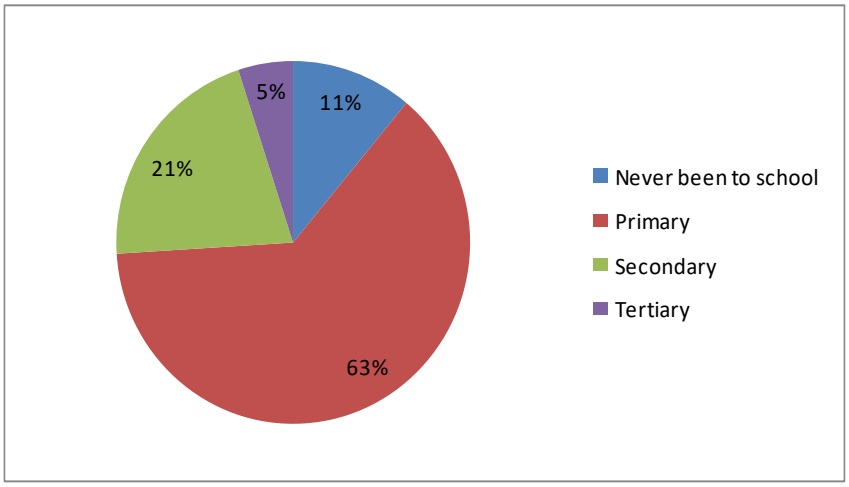

Figure 4: Levels of Education Attained by Household Heads

Source: Source: Field data, 2016

According to Figure 5, the main crops grown both for sale and consumption in Kazungula district were maize (30 percent), groundnuts (26 percent), sweet potatoes (16 percent), mixed beans (14 percent), vegetables (11 percent) and sorghum (3 percent). The crops cultivated in Kazungula are consistent with other studies that have been conducted in the area except that production for cassava was not common and sweet potatoes was very low. The research findings further showed that the main livestock kept by households were chickens, cattle and goats.

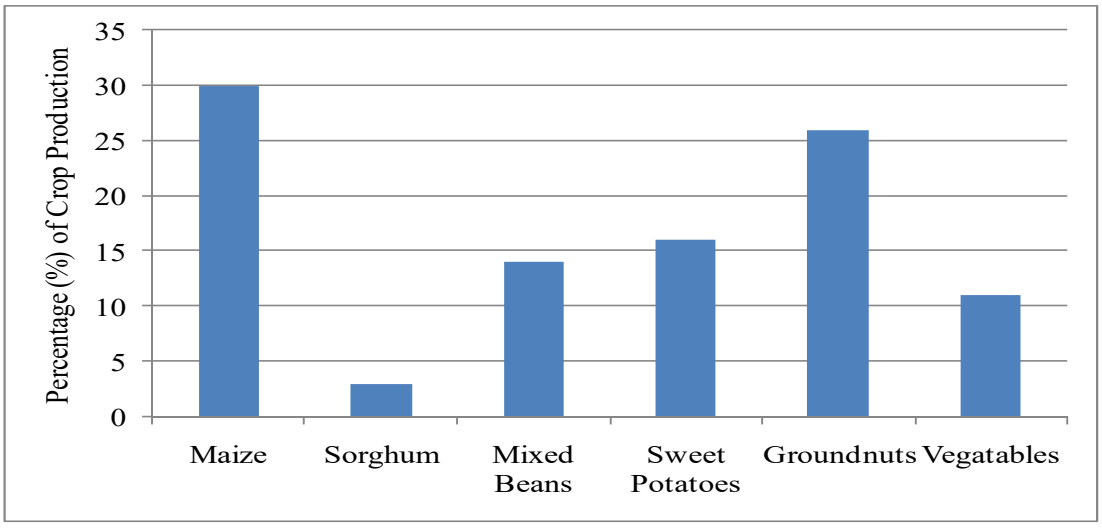

Figure 5: Main Crops Grown for Sale and Consumption in Kazungula

Source: Field data, 2016

5.3 Nature of Climate Change and Climate Variability

The research showed that most of the households interviewed were of the view that the local climate has changed over the last 30 years, for instance 58 percent of the households interviewed indicated that they were experiencing climate change and climate variability while 42 percent were of the view that the district was not experiencing climate change and climate variability (Figure 6). According to Figure 6, majority of the households (58 percent) were experiencing increased occurrence of floods, followed by rainfall and lastly increased temperatures.

Data from the Zambia Meteorological Station for Kazungula (Figures 7 and 8) shows that that temperature has increased by 2°C while rainfall has varied in the last 35 years and reduced by 26.5 percent (1963- 2010) which is slightly higher than the global average temperature of 1.5°C (IPCC: 2007). This may be attributed to the different models that were used, tropical biases and noise in the data (Jochem, 2017 and Dali *et al.*, 2011). The research findings further showed that agricultural production has been adversely affected by both climate change and climate variability due to fluctuating and unstable rain seasons as well as unpredictable weather patterns.

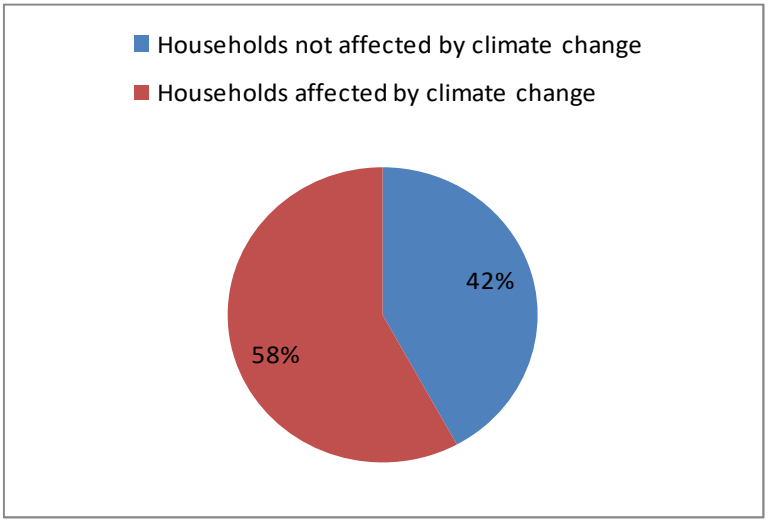

Figure 6: Perceptions on Climate Change and Climate Variability

Source: Field data, 2016

According to the climate data obtained from the Zambia Meteorological Station, temperature has increased by 2°C while rainfall has continued to vary over a long period of time in Kazungula

from 1963- 2010 (Figure 7). Rainfall has also declined by 26.5 percent between 1963-2010 due to continued floods and droughts as well as dry spells experienced in Kazungula. Kazungula has also recorded between 373.6 mm - 593.9 mm of rainfall between 1963-2010 which is way below the long-term average of 600 mm resulting into either dry spells and droughts. Further, it has also recorded between 804 mm -1419.5 mm which is above the 800 mm average resulting into floods and flash floods. According to the MTENR (2007), Region I has also consistently had the most droughts and water scarcity and along the Caprivi strip and regular floods along Lake Kariba. It is therefore, considered to be the most vulnerable region to the impacts of climate change and climate variability.

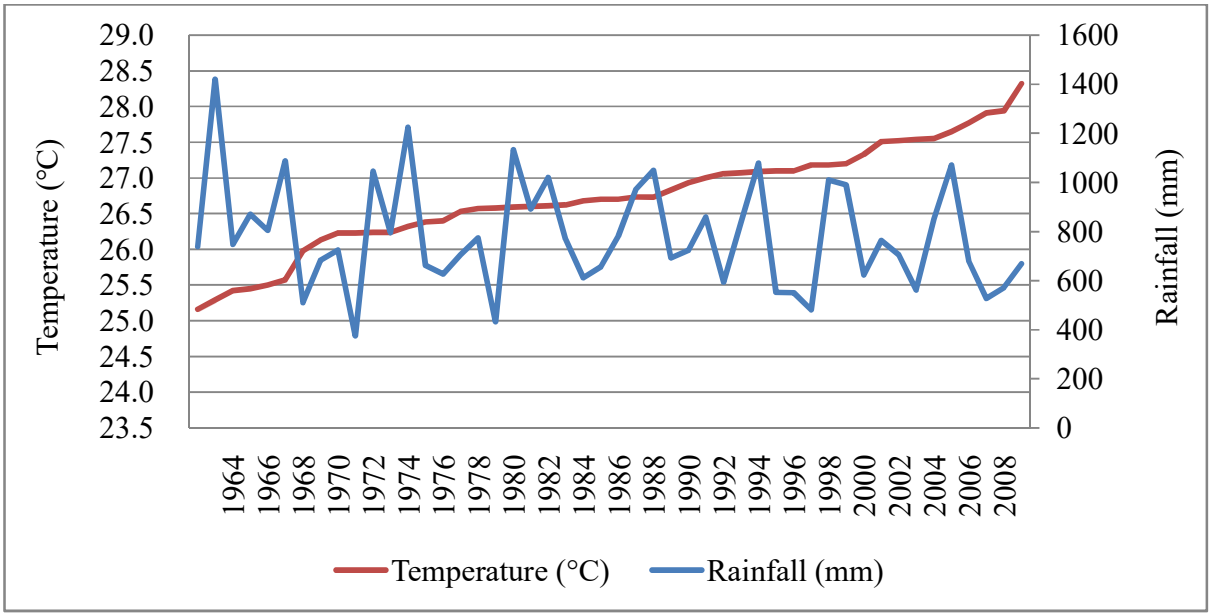

Figure 7: Temperature and Rainfall Long-term Trend Analysis

Source: Adapted from the Zambia Meteorological Department, 2016

The CORDEX raw data that was obtained from the Swedish Meteorological and Hydrological Institute (SHMI) as shown in Figure 8, using two global climate models as well as the observed from 1963 to 2008 shows a significant increase of temperature by 2°C over 30 years.

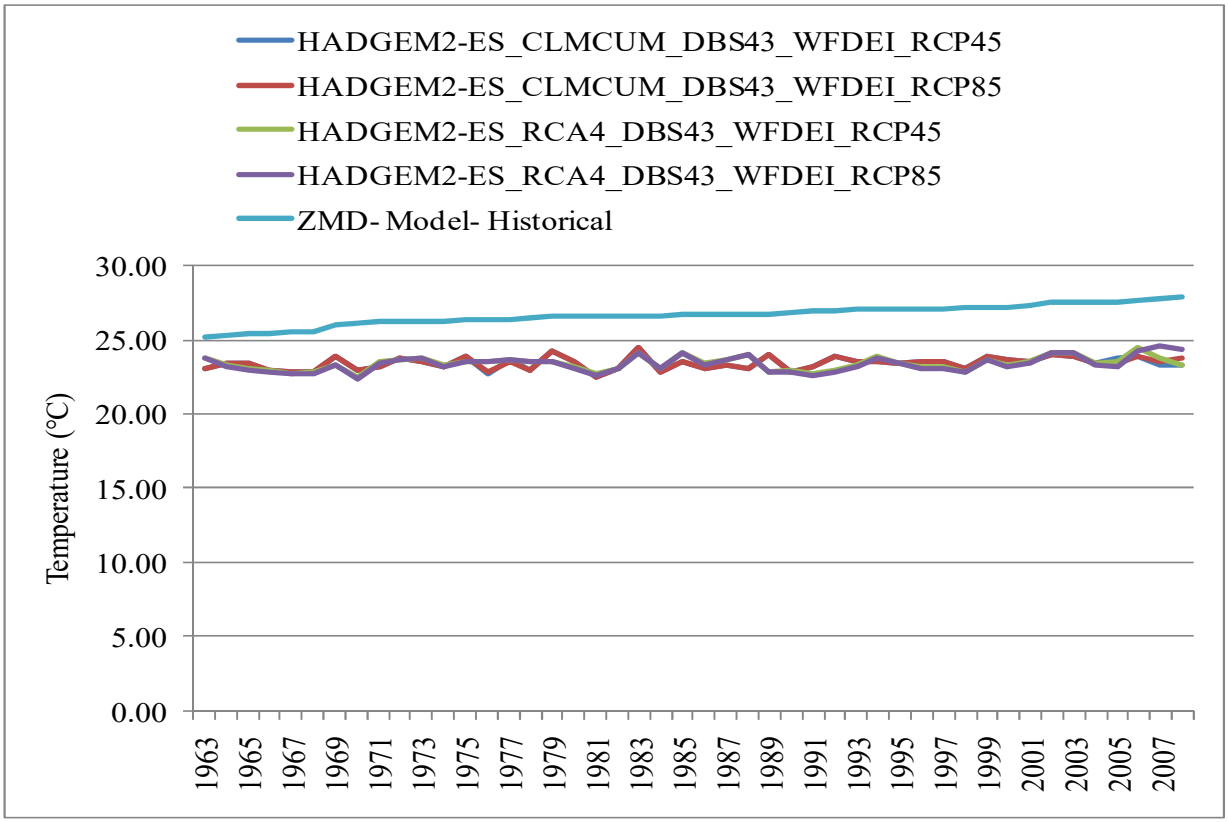

Figure 8: Time Series Analysis of Temperature for Kazungula

Source: Adapted from the Zambia Meteorological Department and CORDEX, 2016

According to Figure 9, in 1988 Kazungula recorded the highest rainfall (1419.5 mm) and recorded the lowest rainfall in 1964 (375.6 mm). The research findings in Figure 9 shows significant anomalies in terms of rainfall performance. Any rainfall recording below 400 mm and above 1000 mm was considered extreme or anomaly, for instance in 1969,1972, 1978, 1986 and 1990 Kazungula recorded above normal rainfall while in 1987, 1992 and 2008 the district experienced significant reductions in rainfall. The climate models and the observed weather data, both show that temperature has decreased while rainfall has increased and varied over time (1962- 2010).

The study showed that most of the households were affected by mainly two climate induced hazards and these are floods and droughts with floods being the most predominant hazard. This finding is in line with Nehemia *et al.* (2015), who observed decreased rainfall in Northern and Southern Africa and a considerable frequent occurrence of floods and droughts. Most of the

households interviewed indicated that they had noticed change in the climate system in the last 30 years which has affected agriculture their main source of income and food. The increased occurrence of floods and dry spells was having negative effects on agricultural production and food security. The perceptions were in line with the long-term changes from the Zambia Meteorological Department and the Global Climate Models.

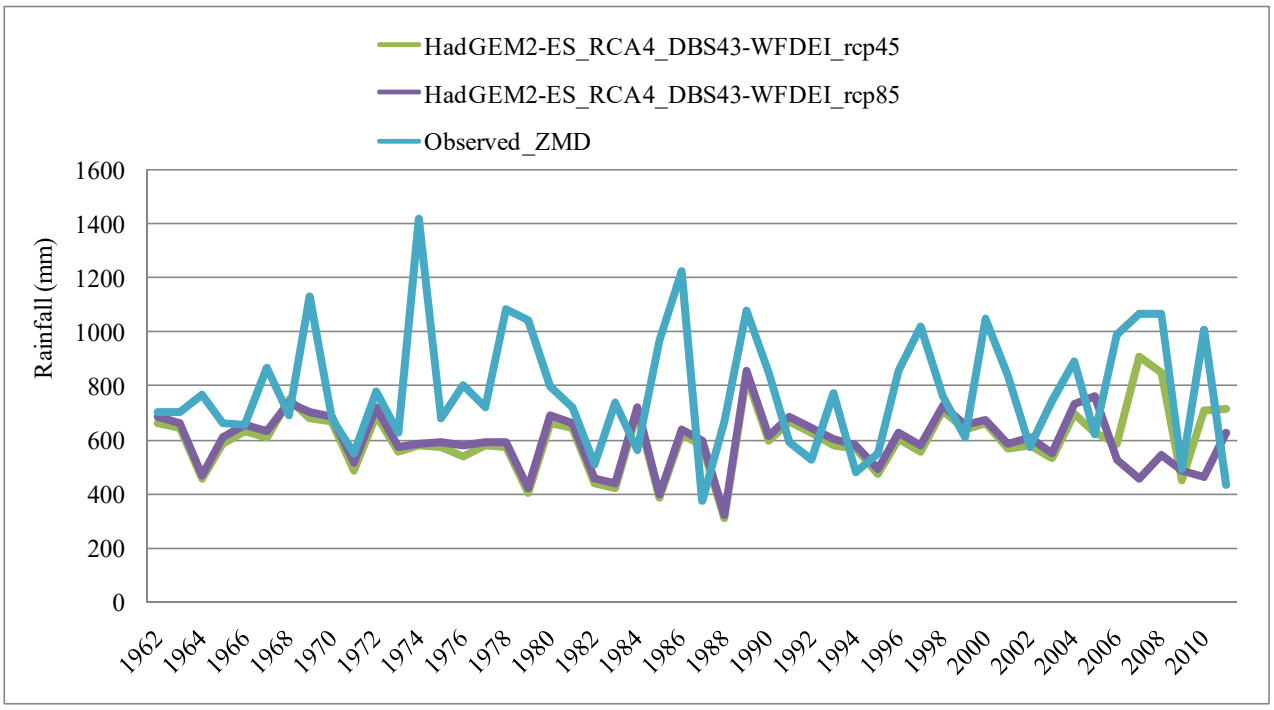

Figure 9: Time Series Analysis of Rainfall for Kazungula

Source: Adapted from the Zambia Meteorological Department and CORDEX, 2016

5.4 Impacts of Climate Change and Climate Variability on Agricultural Production

The analysis of hydro- meteorological data shows both a change in the climate system over a long period of time as well as variability in short term resulting in frequent occurrence of extreme events such floods and droughts. The variability in rainfall and increase in temperature has affected agricultural production through decreased crop yield or crop production, pest infestation on crops and crop failure as shown in Figure 10. Since agricultural production has equally varied due to climate change and climate variability, household food security has equally been affected. For instance between 1976 and 2008 maize production declined by 0.004 percent, groundnuts by 0.06 percent, millet by 0.09 percent and sorghum by 0.01 percent.

Therefore, when climate change and climate variability induced hazards interacts with high poverty levels, poor farming practices, human-animal conflict, pest infestation and high disease incidence due to extreme temperatures it exacerbates the impacts of climate change and climate variability on agricultural production and household food security. In terms of the impacts of climate change and climate variability, the survey showed that the impacts varied from low impact to high impacts.

The observed and Regional Climate Models showed that precipitation has departed from the long-term normals in the last 35 years. The data further showed that temperature has increased over time resulting into frequent and severe dry spells while rainfall has become more variable affecting agricultural production and household food security. Low agricultural production is likely to have long term negative implications on the four pillars of household food security.

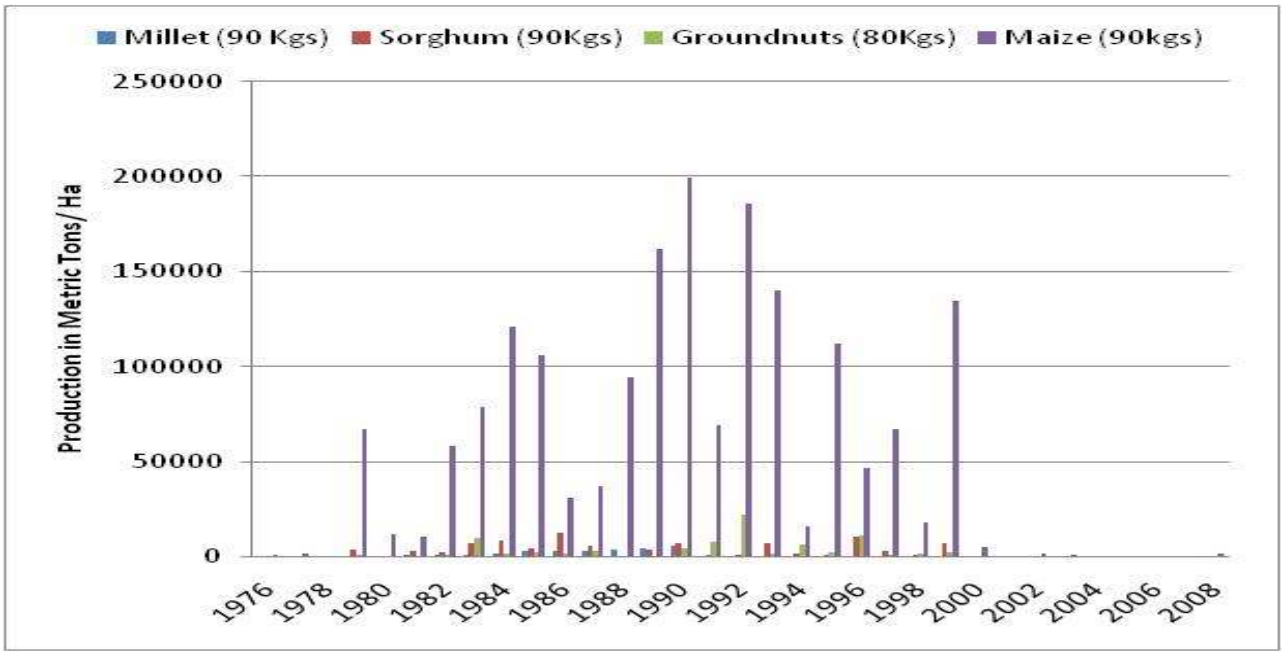

Figure 10: Impacts of Climate Change and Variability on Agricultural Production

Source: Adapted from the Zambia Meteorological Department and CORDEX, 2016

The research findings in Figure 11 shows flood and drier conditions in Kazungula, with areas becoming more drier and flood situations in which maize was flooded hence affecting agriculture production and food security at household level.

Figure 11: Crop Condition under Flood Water

Source: Field data, 2016

The research findings showed that the impacts of climate change were more severe from floods (22 percent) followed by droughts (17 percent), however, 15 percent of the households indicated that they were moderately impacted by both floods and droughts, respectively. These results clearly show that the major climate induced hazards that were impacting agricultural production and household food security were floods and droughts (Figure 12).

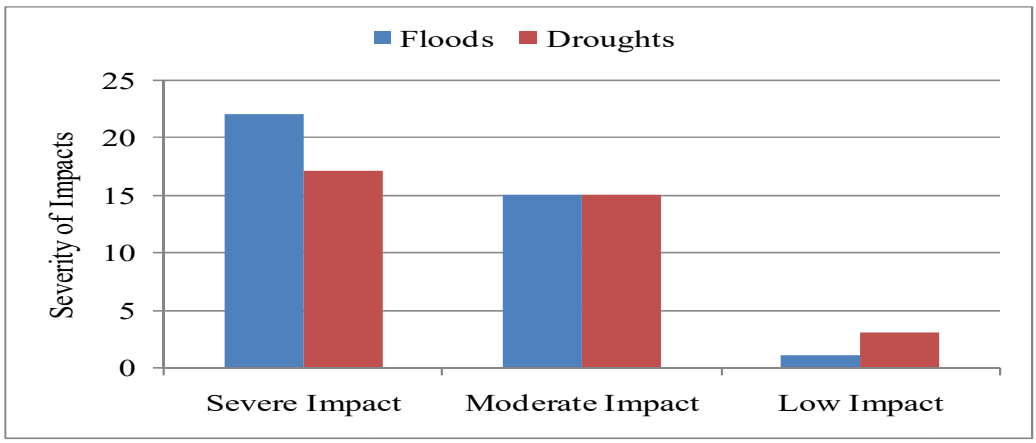

Figure 12: The Severity of the Impacts of Climate Change and Climate Variability

Source: Field data, 2016

5.5 Impacts of Climate Change and Variability on Household Food Security

5.5.1 Access to Food by Households

Using the Food consumption score as a proxy for access to food and dietary needs, the study showed that only 43 percent of the population were better-off and had access to quality food, 33 percent were on borderline while the rest of the households had poor or no access to quality food to meet their daily dietary needs (Figure 13). In other words, 47 percent of the households had poor access to food. Poor access to food may be attributed to high food prices, poor transportation network in the rural areas, lack of markets and inadequate incomes as evident in ZVAC Reports (ZVAC, 2008).

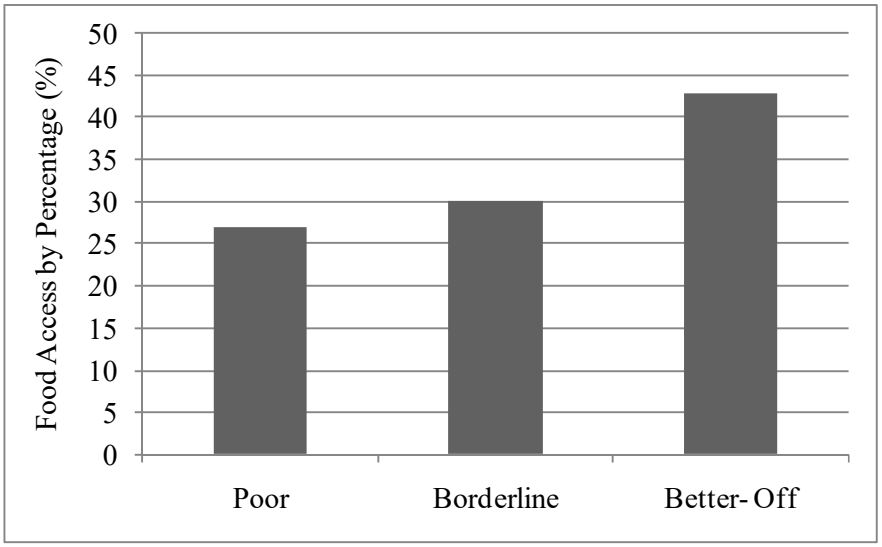

Figure 13: Food Access and Household Dietary Needs

Source: Field data, 2016

The research findings showed that food security was impacted by climate change and climate variability over a period of time (Table 2). The research findings in Table 2 further showed that majority of the households were marginally food insecure (29 percent) and severely food insecure (35 percent). The findings in Table 2 is a summary of a composite of food insecurity indicators which includes a combination of food consumption score, asset wealthy index, food expenditure share and capacity to cope with adverse impacts of climate change and climate variability shows that majority of the people were food insecure (64 percent).

Table 2: Composite of Food Security Indicators

Food Security Indicators	Food Secure	Moderately Secure	Marginally Food Insecure	Severely Food Insecure
Food Consumption Score	27%	0	30%	43%
Asset Wealthy Index	19%	0	42%	39%
Food Expenditure Share	19%	17%	19%	45%
Coping Strategies	42%	21%	25%	13%
Average Food Security Indicator	27%	0.095%	29%	35%

Source: Field data, 2016

The Figure 14 shows that the three main sources of income were crop production, gardening and casual labor translating into 56 percent of the population engaged in crop production, gardening and labor sharing 13 percent, respectively.

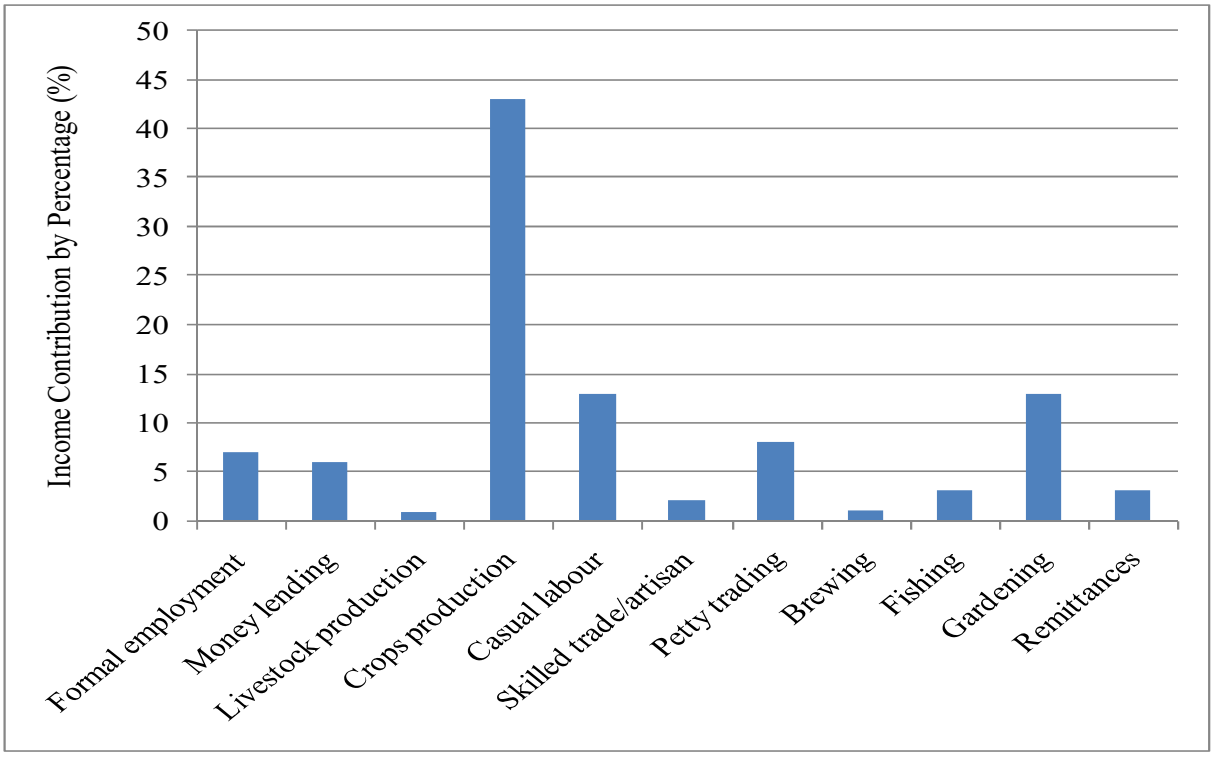

Figure 14: Main Sources of Income

Source: Field data, 2016

5.5.2 Food Availability

The research findings in Figure 15 showed that 91 percent of the households had very low food stocks because they produced below 100 by 50 Kg bags of maize while 5 percent of the households had moderate stocks of maize translating into 100 to 200 by 50 Kg bags of maize compared to the marginally food secure (2 percent) and the food secure (2 percent). Though food was readily available on the market from other surplus districts, it was quite expensive because people were unable to purchase the food stocks due to high prices and high poverty levels at household level. Food can be said to be available when it is affordable at all times by all people but only the better-off had capacity to purchase food. Inadequate food supply affects food nutrition resulting into increased stunting and underweight cases.

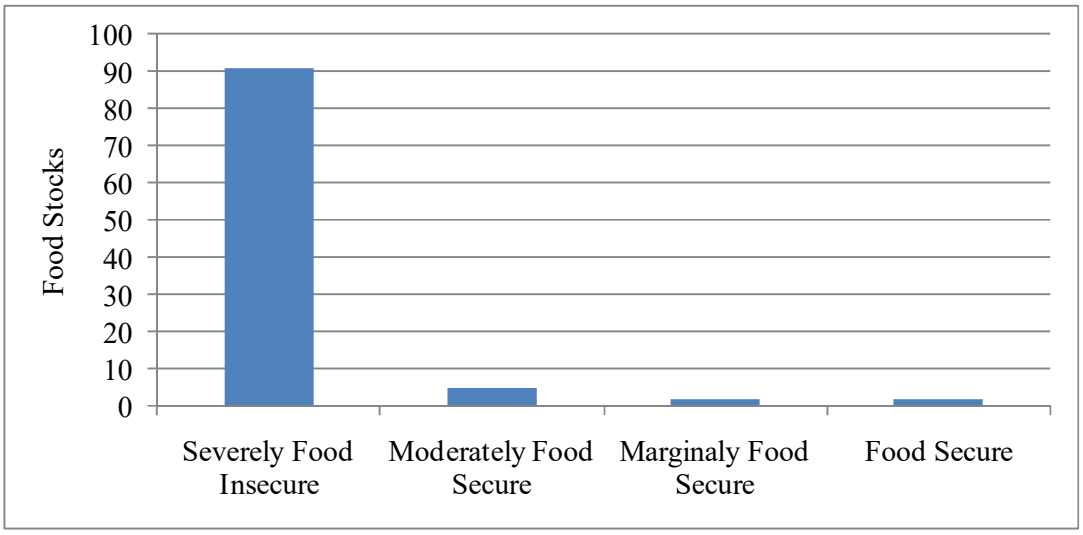

Figure 15: Food Stocks Availability or Production

Source: Field data, 2016

The research findings showed that in terms of food utilization and dietary food diversity which is part of an indicator for measuring household food security, 96 percent of the households did not consume leguminous foods compared to 9 percent who indicated consuming leguminous food groups 24 hours before the field survey (Figure 16). Further, Figure 16 below reveals that majority of the people consumed cereal food groups (27 percent), vegetables (4 percent), Sugar (7 percent), meat (27 percent) oil foods (72 percent) and fish food groups (5 percent) and most of these foods were from purchases from other districts like Lusaka, Choma, Sesheke, Chipata and Ndola. The main factors affecting food availability are low production levels at household level,

poor distribution, low supplies of food, low stock levels and food net trade at community level.

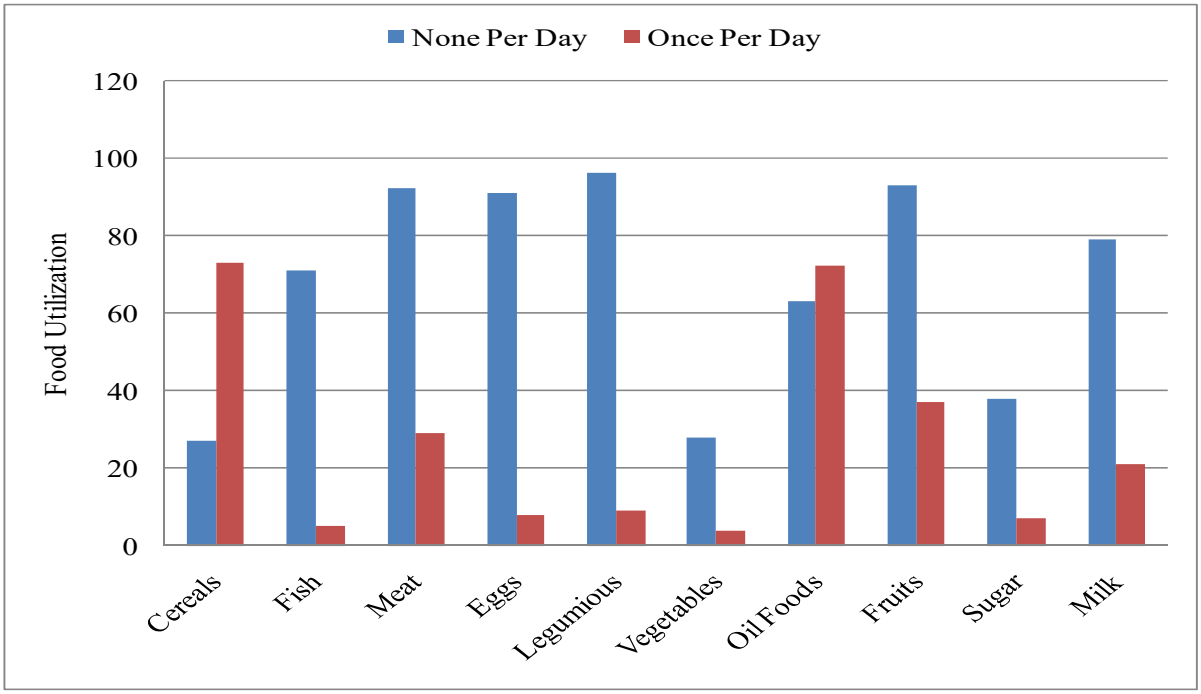

Figure 16: Food Utilization and Dietary Diversity

Source: Field data, 2016

5.5.3 Food Nutrition: Prevalence of Oedema in Under- Five Children

Oedema which is a form of severe acute malnutrition, characterized by swelling of both feet and face of the child is of public health concern due to its consequences. The research revealed that majority of children (98 percent) that were suffering from oedema are female. The research further showed that Stunting, underweight and wasting were highest in children aged between 12-23 months though it affects all children within the age group of 12 to 49 months. These findings showed that the uptake of cereals, oils and wild fruits were very good but theses did not amount to good diet. Food utilization was severely impacted by climate change and climate variability compared to food access which accounted for 57 percent. Therefore, food utilization was equally affected by climate variability hence affecting utilization and nutrition.

5.5.4 Food Stability and Purchase Over Time

The findings in Figure 17 shows that 39 percent of the households were more likely to purchase more maize compared to the previous seasons due to less carryover stocks and low crop yield.

Majority of the households (84 percent) indicated that they had no carryover stocks resulting into food instability. In other words, about 15 percent of the households were likely to purchase less food because they have stable food stocks. However, most of the people were likely to have challenges to purchase food stocks because there main source of income which is crop production was low. Further, food instability is as a result of low agricultural production due to poor rainfall.

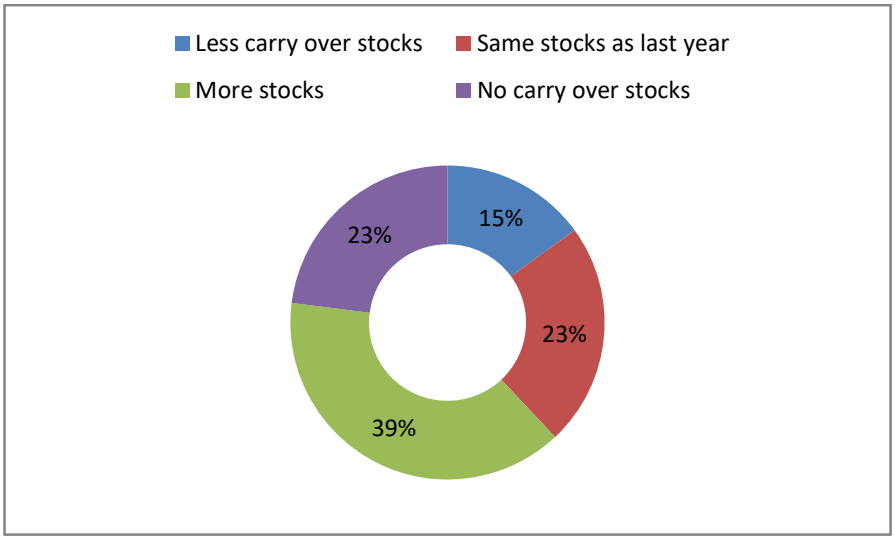

Figure 17: Impacts of Climate Change on Food Stability

Source: Field data, 2016

The findings in Figure 18 shows that though households started running out of food as early as May (3 percent) majority of the households run out of food stocks by November (20 percent), February (15 percent) and March (15 percent). The research revealed that in terms of the impacts of climate change and climate variability on food stability, it was equally under stress. For example, the interviewed households (84 percent) indicated that they had no carryover stocks. In a normal situation food stocks are expected to reach the next harvest season. However, most of the food stocks were expected to run out by November. Low production may force famers to consume their seed stocks and engage in green consumption as a coping strategy.

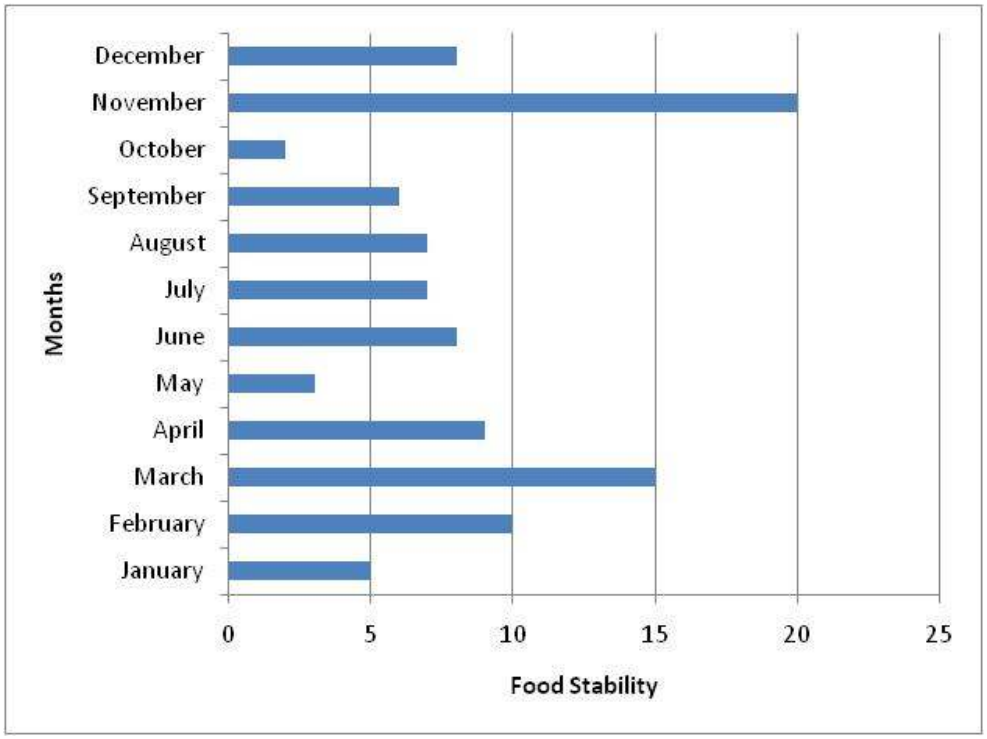

Figure 18: Impacts of Climate Change and Climate Variability on Food Stability

Source: Field data, 2016

The coping strategies employed by households during the occurrence of a hazard is a proxy indicator for food insecurity and adaptive capacity among the affected households. Figure 19 Shows that majority of households (41 percent) did not employ any coping strategies, while 25 percent used crisis coping strategies, 21 percent adopted stress coping strategies and 13 percent engaged in emergency coping strategies. Majority of the households (64 percent) were engaged in stress coping strategies (borrowing money and spending savings), emergency coping strategies (selling one's land) and crisis coping strategies (selling productive assets). Other coping strategies include reduction of meals taken per day by both children and adults, sending children to eat from friends and relatives, reduced expenditure on food and eating less preferred foods.

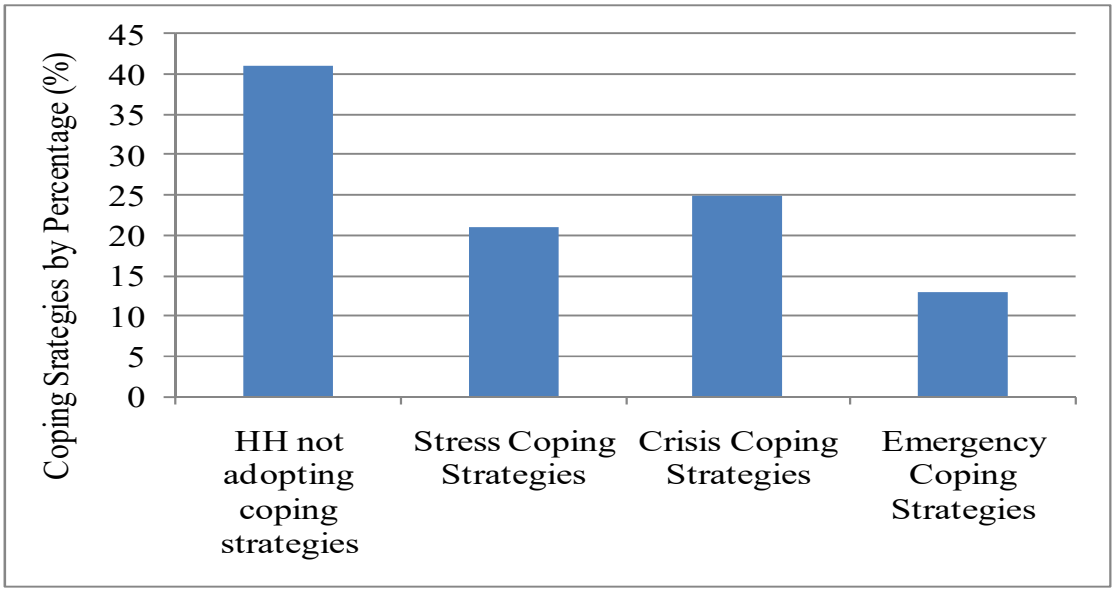

Figure 19: Coping Strategies Employed by Households

Source: Field data, 2016

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter begins with the conclusions of the study and highlights the objectives of the research and the summary of the key findings. The chapter further presents the proposed policy recommendations based on the key findings and the conclusion of the study. The chapter ends with recommending areas were future research related to this study could be undertaken.

6.2 Conclusion

The aim of this study was to assess the impacts of climate change and climate variability on agriculture and household food security as well as the coping strategies of the people in Kazungula district. The objectives of this study was to examine the nature of climate induced hazards affecting agricultural production and household food security, to evaluate the impacts of climate change and climate variability on agriculture and to assess response strategies of households towards adverse impacts of climate change and climate variability in Kazungula district.

To achieve these objectives, this study obtained meteorological and agricultural data from 1963 to 2010 from the Zambia Meteorological Department, the Swedish Meteorological and Hydrological Institute and the Ministry of Agriculture. The analysis of observed data from the Zambia Meteorological Department Weather Stations and the Regional Climate Models from the Swedish Meteorological and Hydrological Institute shows that temperature has increased by 2 °C and rainfall has decreased by 26.5 percent which was in line with IPCC studies which indicate a rise in global surface temperatures between 1.5°C to 2°C (IPCC, 2007).

The study established that climate change and climate variability poses a serious challenge to agricultural production and household food security due to increased variability in annual rainfall patterns and temperatures as well as extreme events such as droughts and floods. Production of maize, millet, sorghum and groundnuts has been declining over the past 30 years (1963- 2010) due to increased occurrence of droughts and floods. Droughts and floods were the main climate induced hazards affecting the people of Kazungula district and their livelihoods depending on

their adaptive capacity.

Climate change and climate variability has impacted negatively on the four pillars of food security (access, availability, utilization and stability). Households had poor access and utilization of food due to low food availability and stability. The asset poor were more vulnerable to impacts of climate change and climate variability compared to the asset rich due to low adaptive capacity.

Agricultural systems and smallholder farmers were already exposed to the adverse impacts of climate change and climate variability and had low adaptive capacity to cope with the impacts. Most of the households were employing crisis, stress and emergency coping strategies which was a clear indication that people were being threatened with food insecurity.

6.3 Recommendations

Arising from the above conclusions, the study recommends the following:

i. Government should invest in climate smart agriculture to help the local communities adapt to adverse impacts of climate change and climate variability,

ii. In order to increase agricultural production, government should encourage the local communities to intensify the production of drought tolerant crops like cassava, sorghum and millet which is still low compared to maize production,

iii. The Government in collaboration with stakeholders with the involvement of the local communities should invest in small dams and water harvesting technologies to enhance agricultural production and narrow the food gap,

iv. In order to ensure continued food security in Kazungula, local communities should invest in alternative livelihoods like fishing and livestock production, and

v. Promote alternative livelihoods for the well-being of the local communities and promotion of nutrition.

6.4 Future Research

The survey recommends for further research on long term adaption strategies under different climate change scenarios.

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APPENDICES

Appendix 1: Household Questionnaire

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

QUESTIONNAIRE No: ☐☐☐

MASTER OF SCIENCE IN ENVIRONMENTAL AND NATURAL RESOURCES MANAGEMENT

IMPACTS OF CLIMATE VARIABILITY ON AGRICULTURE AND HOUSEHOLD FOOD SECURITY IN KAZUNGULA

i. QUESTIONNAIRE IDENTIFICATION PARTICULARS	ii. CODE NUMBER
1. PROVINCE NAME	☐
2. DISTRICT NAME	☐☐☐
3. CONSTITUENCY NAME	☐☐☐
4. WARD NAME	☐☐
5. CSA NUMBER	☐☐
6. SEA NUMBER	☐
7. HOUSEHOLD NUMBER	☐☐☐
8. COMMUNITY/ VILLAGE NAME	……
9. TOTAL NUMBER OF PERSONS WHO LIVE IN THIS HOUSEHOLD (INCLUDE USUAL MEMBERS ABSENT)	☐☐
10. ENUMERATOR'S NAME……..… DATE OF INTERVIEW	☐☐ ☐☐ ☐☐

SECTION 1: HOUSEHOLD ROSTER						
INTRODUCTION: I would like to start the interview by asking you questions about yourself and other usual members of the household						
		1	**2**	**3**	**4**	**5**
SERIAL NUMBER OF RESPONDENT	**NAME**	How old is………now? **RECORD EXACT AGE OF HOUSEHOLD MEMBERS** **YEAR OF BIRTH** **AGE**	What is the relationship of ……to the head of the household? 1 = HEAD 2 =SPOUSE 3 = OWN CHILD 4 = STEP CHILD 5 = GRAND CHILD 6 = BROTHER/SISTER 7 = NIECE/NEPHEW 8 = BROTHER/SISTER-IN LAW 9 = PARENT 10 = PARENT-IN-LAW 11 = COUSIN 12 = OTHER RELATIVE 13 = MAID/NANNY/HOUSE-SERVANT 14= NON-RELATIVE	Sex of the individual members of the household 1 = MALE 2 = FEMALE	What type of disability does …………….? got? 1 = Blind 2 = Partially Sighted 3 = Deaf and Dumb 4 = Crippled 5 =Mentally Retarded 6 = Mentally Ill 7 = None 8 = OTHER SPECIFY, ……………………………… …………………………	Indicate marital status of those aged 12 years and above only 1 = Single 2 = Married 3 = Separated 4 = Divorced 5 = Widowed 6 = Other, specify………………
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐

SECTION 1: HOUSEHOLD ROSTER (CONTINUED)						
INTRODUCTION: I would like to start the interview by asking you questions about yourself and other usual members of the household						
		1	2	3	4	5
SERIAL NUMBER OF RESPONDENT	**NAME**	How old is……now? RECORD EXACT AGE IN COMPLETED YEARS FOR THOSE 1 YEAR AND ABOVE, 0 FOR THOSE LESS THAN 12 MONTHS. **YEAR OF BIRTH** **AGE**	What is the relationship of ……to the head of the household? 1 = HEAD 2 SPOUSE 3 = OWN CHILD 4 = STEP CHILD 5 = GRAND CHILD 6 = BROTHER/SISTER 7 = NIECE/NEPHEW 8 = BROTHER/SISTER-IN LAW 9 = PARENT 10 = PARENT-IN-LAW 11 = COUSIN 12 = OTHER RELATIVE 13 = MAID/NANNY/HOUSE-SERVANT 14= NON-RELATIVE	Sex of the individual members of the household 1 = MALE 2 = FEMALE	What type of disability has …….?Got? 1 = Blind 2 = Partially Sighted 3 = Deaf and Dumb 4 = CRIPPLED 5 = MENTALLY RETARDED 6 = MENTALLY ILL 7 = NONE 8= OTHER SPECIFY, ……	Indicate marital status of those aged 12 years and above only 1 = Single 2 = Married 3 = Separated 4 = Divorced 5 = Widowed 6 = Other, specify……
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐
☐☐		☐☐☐☐ ☐☐	☐☐	☐		☐

SECTION 2A: NATURE OF CLIMATE INDUCED HAZARDS AFFECTING AGRICULTURE AND HOUSEHOLD FOOD SECURITY					
INTRODUCTION: I am now going to ask you about household experience with hydro- meteorological hazards/ disasters					
	HAZARDS	1. Has this household been affected by any of the following hazards/disaster in the last 10 years? 1 = YES 2 = NO – *go to the next hazard*	**2. In which year and for how long was your household affected? (**Period of Impact**)** **[RECORD DURATION IN DAYS, IF LESS THAN 1 DAY ENTER 00** **2a. Has household Recovered?** 1= Recovered 2=Partially Recovered3= Not recovered **YEAR** **DAYS**	3. What was the impact of the hazard on agriculture and household food security? 2 = Moderate Impact 3 = Low Impact	4.How many times has the identified hazard affected you in the last 5 years **(number i.e. 1 time, 2 times, 3 times, 4 times, 5 times)?**
1.	Floods	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐
2	Flash Floods	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐
3	Prolonged Dry Spells	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐
4.	Drought	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐
5.	Pest Infestation	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐
6.	Disease Epidemic (Dysentery, Cholera meningitis, etc)	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐
7.	Livestock diseases	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐
8.	Other (Specify)	☐	☐☐☐☐ ☐☐☐ ☐	☐	☐

	SECTION 2: NATURE OF CLIMATE INDUCED HAZARDS (CONTINUED)		
	SECTION 2B: CLIMATE VARIABILTY		
1.	Has the household noticed any climate variability over the last 10 years?	1 = Yes – *go to question 37* 2 = No – *go to question 38* ☐	3. What adaptation measures have you put in place to deal with climate variability?
2.	What three 2 elements of climate have changed? *Please rank in the order of importance.*	1 = Reduction in rainfall 2 = Increase in rainfall 3 = Reduction in temperatures ☐ 4 = Increase in temperatures 5 = Reduction in water levels (i.e. dams, rivers) ☐ 6 = Increase in water levels (i.e. dams, rivers) ☐ 7 = Reduction of water catchment areas 8 = Increase of water catchment areas 9 = Other, specify:_____	

SECTION 2: NATURE OF CLIMATE INDUCED HAZARDS (CONTINUED)					
	HAZARDS	4. What did this experience of a hazard lead to? 1 = Loss/decrease in income 2 = Loss/decrease in assets 3 = Loss/decrease in both income/assets 4 = Loss of life 5 = No Change at all – *goto the NEXT HAZARD*	5. Did the household's experience of the hazard create a decrease in their ability to produce or purchase enough food to eat? 1 = YES 2 = NO	6. What were the three main response/ coping strategies for the household to the impact of the hazard on agriculture and household food security?	7. Has your household recovered from the impact of the hazard? 1 = NOT RECOVERED 2 = PARTIALLY RECOVERED 3 = COMPLETELY RECOVERED
1.	Floods	☐	☐	**1**..... **2**..... **3**.....	☐
2.	Drought	☐	☐	**1**..... **2**..... **3**.....	☐
3.	Flash Floods	☐	☐	**1**..... **2**..... **3**.....	☐
4.	Prolonged Dry Spells	☐	☐	**1**..... **2**..... **3**.....	☐
5.	Pest Infestation	☐	☐	**1**..... **2**..... **3**.....	☐
6.	Disease Epidemic (Dysentery, Cholera meningitis, etc)	☐	☐	**1**..... **2**..... **3**.....	☐
7.	Livestock diseases	☐	☐	**1**..... **2**..... **3**.....	☐
8.	Other (Specify)	☐	☐	**1**..... **2**..... **3**.....	☐

IMPACTS AND VULNERABILITY OF AGRICULTURE TO CLIMATE VARIABILITY

SECTION 3: SOURCES OF HOUSEHOLD INCOME

Income Source Codes

1 = Formal Employment
2 = Money Lending
3 = Livestock Production
4 = Crop Production (Cash & Food)
5 = Casual Labour
6 = Begging
7 = Skilled trade/Artisan
8 = Petty Trading
9 = Brewing
10 = Fishing
11 = Gardening
12 = Maid/Garden Helpers
13 = Hair dressing (Both Barber Shop and Saloon)
14 = Stone crashing
15 = Restaurants/Hotels
16 = Remittances
19 = Other, specify_____

1	What are your household three (3) **most important** income sources?	|____||____| 1	|____||____| 2	|____||____| 3
2	Has there been any change in the total household income in the past between the reference year and the bad year? *1 = Yes, increased income* *2 = Yes, decreased income* *3 = No– go to section 4*			☐
3	What are the main causes of this change? *Please indicate**1** = Yes or **2** = No in an appropriate box(es)*	1 = Reduced incomes |____| 2 = Reduced production |____| 3 = Reduced employment |____| 4 = Was hit by a disaster |____| 5 = Loss of a bread winner |____| 6 = Lowering of prices for producers |____| 7 = Local conflict |____| 8 = Closing of borders |____| 9 = Increased production |____| 10 = Increased employment |____| 11 = Increased incomes |____| 12 = Other, specify:_____ |____|		

SECTION 4: PURCHASE AND EXCHANGE of staple and non- staple food for household consumption (Expenditure)								
Commodity (e.g. cereals, pulses, oil, sugar, meat)	Unit of measure and weight	Frequency per month	Duration / number of months	which months	Total Kilos purchased/ consumed	% of annual HH food needs	Price/ Kg	Total Cost
LABOR FOR FOOD								

SECTION 5: EXPENDITURE PATTERNS				
Main Expenditure Categories	Expenditure Patterns on non- food items			
	Quantity (Unit) purchased(a)	Frequency Purchased (b)	Price Per Unit ©	Total = (a+b+c)
Main food items				
Tea/ Coffee				
Salt, condiments				
Household items				
Soap				
Vaseline/ lotions				
Candles				
Paraffin				
Firewood/ Charcoal				
Grinding of grain				
Water				
Utensils/pots				
Inputs				
Livestock drugs, veterinary				
Land rental				
Tools				
Seeds				
Fertilizer				
Agricultural labor				
Business investment				
Livestock purchase				
Fishing equipment maintenance				
Social Services				
School (fees, Uniforms, etc)				
Medicine				
Taxes, levies				
Other expenditure				
Loan repayments				
Savings contributions				
Battery charging				
Airtime				
Gifts				
Clothing				
Tobacco, bear				
Festival/ celebrations				
Other				
Total Expenditure				

SECTION 6: HOUSEHOLD ASSETS

INTRODUCTION: I am now going to ask you questions about whether or not your household owns the following assets

	ASSETS	1.Does this household own any of the following assets? 1 = YES 2.= NO – *go to* ***NEXT ASSET***	2. How many of these assets does this household own?	3. What was the purchasing price for each of your assets? **[INDICATE TOTAL VALUE]**
1	Plough	☐	☐	
2	Crop sprayer	☐	☐	
3	Boat	☐	☐	
4	Canoe	☐	☐	
5	Fishing net	☐	☐	
6	Bicycle	☐	☐	
7	Motor cycle	☐	☐	
8	Motor vehicle	☐	☐	
9	Tractor	☐	☐	
10	Radio	☐	☐	
11	Televisio n Set	☐	☐	
12	Grinding /Hammer	☐	☐	
13	Electric Iron	☐	☐	
14	Non-electric	☐	☐	
15	Refrigera tor	☐	☐	
16	Cellular phone	☐	☐	
17	Sewing machine	☐	☐	
18	Knitting Machine	☐	☐	
19	Scotch cart/Oxc	☐	☐	
20	Electric Stove	☐	☐	
21	Video Player/ DVD	☐	☐	

SECTION 6: HOUSEHOLD ASSETS (Continued)				
	ASSETS	1.Does this household own any of the following assets? 1 = YES 2.= NO – *go to* ***NEXT ASSET***	2. How many of these assets does this household own?	3. What was the purchasing price for each of your assets? **[INDICATE TOTAL VALUE]**
22	Disc Harrow			
23	Hoe			
24	Axe			
25	Gun			
26	Pick			
27	Hammer			
28	Shovel/spade			
29	Wheel barrow			
30	Hand driven tractor			
31	Water pump			
32	Hand Mill			
33	Sheller			
34	Rump press/oil expeller			
35	Hand saw			
36	Carpentry Plane			
37	Bed			
38	Mattress			
39	Solar Panel			
40	Commercial Building			
41	Residential Building			
42	Oxen			
43	Donkey			
44	Other (Specify)			

SECTION 7: AGRICULTURAL PRODUCTION AND FOOD SECURITY			
INTRODUCTION:I am now going to start by asking you questions about how your household uses Agricultural Land			
1.	Does any member of your household have access to any arable agricultural land?	1 = YES 2 = NO– *go to question* 6a	☐
2.	How much agricultural land does your household have?	RECORD LAND IN HECTARE 1 Lima = 0.25 ha 4 Lima = 1 ha **(See land conversion)** 1 Acre = 0.405 ha 2.5 Acres = 1 ha	☐
3.	Of the total agricultural land, available to the household, how much is used for following; [RECORDLAND TO THE HECTARE]	Irrigation agriculture	☐
		Rain fed	☐
4.	What are the four main implements/equipments used for cultivating/tilling the land? *Please indicate the implement code in the appropriate box.*	1 = CONVENTIONAL HAND HOE 1st 2 = ANIMAL DRAUGHT POWER (PLOUGH) 2nd 3 = ANIMAL DRAUGHT POWER (RIPPER 3rd 4 = TRACTOR (PLOUGH) 4th 5 = TRACTOR (RIPPER) 6 = OTHER (SPECIFY):_____	☐ ☐ ☐ ☐
5.	Where do you store your harvest?	1= Indoors – in basket / bags 2 = Indoors – open storage 3 = In outside storage hut 4 = In rice bank/communal storage 5 = Other (Specify)……	☐ ☐ ☐ ☐

SECTION 7B: AGRICULTURAL PRODUCTION (Continued)			
INTRODUCTION:I am now going to ask you questions about Livestock and Poultry Production			
LIVESTOCK/POULTRY TYPES		**CATEGORY AND CODE**	**NUMBER OF LIVESTOCKS**
6.	Does your household own any livestock?	1 = YES 2 = NO ☐	
7.	Does the household own any of the following livestock?	1 = YES 2 = NO – *go to the NEXT TYPE OF LIVESTOCK*	
A	Cattle	☐	NUMBER OF CATTLE
B	Goats	☐	NUMBER OF GOATS
C	Pigs`	☐	NUMBER OF PIGS
D	Sheep	☐	NUMBER OF SHEEP
E	Traditional/free range Chickens	☐	NUMBER OF CHICKENS
F	Broiler Chickens	☐	NUMBER OF CHICKENS
G	Other Chickens (Layers, Parent Stock)	☐	NUMBER OF CHICKENS
H	Ducks & geese	☐	NUMBER OF DUCKS & GEESE
I	Guinea fowls	☐	NUMBER OF GUINEA FOWLS
J	Any other poultry (e.g. turkey, rabbits, and pigeons)	☐	NUMBER OF OTHER POULTRY

SECTION 8. FOOD ACCESS

1. Are there any markets in this community? 1 = Yes 2 = No, go to Q13. |__|

2. Are these markets easily accessible? 1 = Yes go to Q10 2 = No |__|

3. If **No to Q8**, Why?
1= impassable roads **2** = broken bridges **3** = destruction of market infrastructure
4 = too far |__|
5 = Other, specify: …….

4. Is the staple food readily available on the market? 1 = Yes **2=**No |__|

5. Where does the staple food come from? 1 = Yes **2=**No |__|

6. **C**ompare the current prices of staple foods to same time last year and insert price ranges in the table below:

Commodity	**Unit**	**Price in the good year**	**Price in a bad year**	**Reason for price variation** (e.g. **1** = Increased supply, **2** = Reduced supply, **3** = Reduced demand, 4= Increased demand, **5** = Other, specify in the appropriate row
Maize				
Sorghum				
Millet				
Rice (Polished)				
Cassava (Chips)				

SECTION 9: OWN FOOD PRODUCTION

2016							2015						2014					
Food and Cash Crops from own production eg Maize, Cassava, Cassava (per 50 kg)	Total quantity produced	Quantity Sold	Price/ 50 Kg	Cash Income	Balance consumed in Kg	Percentage of food needs	Total quantity produced	Quantity Sold	Price/ 50 Kg	Cash Income	Balance consumed in Kg	Percentage of food needs	Total quantity produced	Quantity Sold	Price/ 50 Kg	Cash Income	Balance consumed in Kg	Percentage of food needs
Total Crop Food and Income																		

C. FOOD CROP AVAILABILITY

6. What is the current staple food availability in the area compared to May 2014?

6a. Staple food/crop

Food Type	**Own Production**		**Other indirect sources** ***(e.g. Casual work, barter system, Relief food, inter district etc)*** 1 = Less 2 = Same 3 = More	**Other indirect sources** **Comments (Specify)**
	1 = Less 2 = Same 3 = More	*Comments (Specify)*		
Maize				
Sorghum				
Millet				
Cassava (areas under mature cassava)				
Rice (polished)				
Other, specify				

15. SUPERVISOR'S NAME……DATE OF CHECKING	**DD** **MM** **YY** ☐☐ ☐☐ ☐☐

Appendix 2: Community Questionnaire

THE UNIVERSITY OF ZAMBIA

IMPACTS OF CLIMATE VARIABILITY ON AGRICULTURE AND HOUSEHOLD FOOD SECURITY IN KAZUNGULA

Province	District	Enumerator(s)
Rural / Urban	Date	

1. HAZARDS

Drought Flood Flash floods Hailstorms	Animal Diseases Prolonged Dry Spells Epidemics (Human) Crop Pests		
Year	Seasonal Performance (1-5*)	Events	Response: What did people do themselves to cope with the problem?
2014/ 2015			
2013/ 2014			
2012/ 2013			
2011/2012			
2010/2011			

Rank all the seasons relative to each other

5=Excellent season for household food security (due eg to bumper yields, good rains, good prices)

4=A good or above average season for household food security

3=An average season in terms of food security

2=A below average season for household food security

1=A poor season (eg due to drought, flooding, pest attack) for household food security

Which year from the above years would you consider as:

Reference year/ typical/ average year:.....
Bad year:.....
Good year:.....

2.0 COPING STRATEGIES

2.1 What are the three main hazards this district experienced in the last five (5) seasons **(2011-2015)**? e.g.

Drought	Prolonged	Hail Storm	Market Events
Epidemics	Dry Spells	Epidemics(human)	
(livestock)	Crop Pests	Wild Animals	
Flood	Flash floods	Other specify	

	Hazard 1	**Hazard 2**	**Hazard 3**
HAZARD MAPPING			
HAZARD IMPACT	**1, 2, 3**	**1, 2, 3**	**1, 2, 3**
2.2 What was the impact on the district? Why **1**=Severe **2**=Moderate **3** = Low			
2.3 Who was most affected? *(in order of importance)* (Farmers, pastorals, businessmen, youth, women, etc.)			
2.4 How did the district respond to the hazard (s)?			
2.9. What measures has the district put in place to minimize the impact of the hazard?			

3. LIVELIHOODS

Where livelihood describes their means of living i.e. how people access food and income e.g. farming, informal Mining (stone crushing), Formal Mining, Fishing, gardening, Formal employment (specify), Informal employment (specify), trading (small or large) etc

	3.1 What are the three main livelihoods in order of priority?	Percentage of people engaged in this livelihood
1		
2		
3		

4. Climate variability and food security in Kazungula using proportional piling

% of households who are severely food insecure and which wealthy group is the most affected and give reasons	**% of people who are moderately food insecure and which wealthy group is the most affected and give reasons**	**% of people who food secure and which wealthy group is the most affected and give reasons**
% of households highly vulnerable to the impacts of climate variability and which wealthy group is the most affected and give reasons	**% of households moderately vulnerable to the impacts of climate variability and which wealthy group is the most affected and give reasons**	**% of households lowly vulnerable to the impacts of climate variability and which wealthy group is the most affected and give reasons**

5. MARKETING

1. How many functional markets does the district have? ☐

2. Are these markets adequate? (If Yes, go to 4.2.4) **1**=Yes **2** = No ☐

3. If No, explain

……

……

……

6. AGRICULTUREFACILITIES

6.3.1. What agricultural facilities are available (e.g. dip tank, training facility)?	6.3.2. Are these facilities adequate? **1**= Yes **2**= No	6.3.3. What is the condition of the facility? **1**= Good, **2**= fair, **3**=poor	6.3.4. What improvement would you like to be made to the existing facilities?

1.Give the crop production figures for the three main crops in order of importance produced in the last five years.

Main Food and Cash crop	Yield/ hectare in reference year	Yield/ hectare in bad year	Yield/ hectare in a good year	Seed requirement/ hectare

2. Over the last five years which three major crop pests and diseases has the district experienced? (Fill in the table below) (Multiple answers allowed)

Pest	Crop Affected	% crop losses
Diseases	Crop Affected	% crop losses

4. Over the last five years what have been the **three (3) major** livestock diseases? Give the most affected ward/camp and percentage of livestock affected? (Fill in the table below) (Multiple answers allowed)

Disease Name	% livestock affected

6. NUTRITION

% of malnourished children	**% stunted children**	**% of children on supplementary feeding**

7. Which expenditure items could be reduced in a bad year?

8. What measures should be put in place to copy with the adverse effects of climate variability

9. Complete a short WEALTHY BREAK DOWN using proportion pilling

VERY POOR	**POOR**	**MIDDLE**	**BETTER- OFF**

END OF INTERVIEW

Appendix 3: Key Informants Questionnaire
THE UNIVERSITY OF ZAMBIA

IMPACTS OF CLIMATE VARIABILITY ON AGRICULTURE AND HOUSEHOLD FOOD SECURITY IN KAZUNGULA

Province	District	Enumerator(s)
Rural / Urban	Date	

1. HAZARDS

Drought Flood Flash floods Hailstorms	Animal Diseases Prolonged Dry Spells Epidemics (Human) Crop Pests		
Year	Seasonal Performance (1-5*)	Events	Response: What did people do themselves to cope with the problem?
2014/ 2015			
2013/ 2014			
2012/ 2013			
2011/2012			
2010/2011			

Rank all the seasons relative to each other

5=Excellent season for household food security (due eg to bumper yields, good rains, good prices)

4=A good or above average season for household food security

3=An average season in terms of food security

2=A below average season for household food security

1=A poor season (eg due to drought, flooding, pest attack) for household food security

2.0 COPING STRATEGIES (Ask all the five sectors)

2.1 What are the three main hazards this district experienced in the last five (5) seasons **(2011-2015)**? e.g.

Drought	Prolonged	Hail Storm	Market Events
Epidemics (livestock)	Dry Spells	Epidemics(human)	
Flood	Crop Pests	Wild Animals	
	Flash floods	Other specify	

	Hazard 1	**Hazard 2**	**Hazard 3**

HAZARD MAPPING						
HAZARD IMPACT	**1, 2, 3**		**1, 2, 3**		**1, 2, 3**	
2.2 What was the impact on the district? Why **1**=Severe **2**=Moderate **3** = Low						
2.3 Who was most affected? *(in order of importance)* (Farmers, pastorals, businessmen, youth, women, etc.)						
2.4 How did the district respond to the hazard (s)?						
2.9. What measures has the district put in place to minimize the impact of the hazard?						

3. LIVELIHOODS

Where livelihood describes their means of living i.e. how people access food and income e.g. farming, informal Mining (stone crushing), Formal Mining, Fishing, gardening, Formal employment (specify), Informal employment (specify), trading (small or large) etc

	3.1 What are the three main livelihoods in order of priority?	Percentage of people engaged in this livelihood
1		
2		
3		

4. Climate variability and food security in Kazungula using proportional piling

% of households who are severely food insecure and which wealthy group is the most affected and give reasons	**% of people who are moderately food insecure and which wealthy group is the most affected and give reasons**	**% of people who food secure and which wealthy group is the most affected and give reasons**
% of households highly vulnerable to the impacts of climate variability and which wealthy group is the most affected and give reasons	**% of households moderately vulnerable to the impacts of climate variability and which wealthy group is the most affected and give reasons**	**% of households lowly vulnerable to the impacts of climate variability and which wealthy group is the most affected and give reasons**

5. MARKETING

1. How many functional markets does the district have? ☐

2. Are these markets adequate? (If Yes, go to 4.2.4) **1**=Yes **2** = No ☐

3. If No, explain

……

……

……

4. Do local authorities charge market levies (where applicable urban / rural)? **1** = Yes **2** = No ☐

6. AGRICULTUREFACILITIES

4.3.1. What agricultural facilities are available (e.g. dip tank, training facility)?	4.3.2. Are these facilities adequate? **1**= Yes **2**= No	4.3.3. What is the condition of the facility? **1**= Good, **2**= fair, **3**=poor	4.3.4. What improvement would you like to be made to the existing facilities?

1.Give the crop production figures for the three main crops in order of importance produced in the last five years.

Main Food and Cash crop	Yield/ hectare in reference year	Yield/ hectare in bad year	Yield/ hectare in a good year	Seed requirement/ hectare

2. Over the last five years which three major crop pests and diseases has the district experienced? (Fill in the table below) (Multiple answers allowed)

Pest	Crop Affected	% crop losses
Diseases	Crop Affected	% crop losses

3. NUTRITION

% of malnourished children	**% stunted children**	**% of children on supplementary feeding**

END OF INTERVIEW