THE IMPLICATIONS OF CLIMATE VARIABILITY AND CHANGE ON RURAL HOUSEHOLD FOOD SECURITY IN ZAMBIA: EXPERIENCES FROM CHOMA DISTRICT, SOUTHERN PROVINCE.

BY

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DECLARATION

This research project is my own original work and has not been presented for award of degree in any other university.

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DEDICATION

To my Mum and Dad, young brothers and sisters for being the inspiration behind this work.

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ABSTRACT

The study analyzes the implications of climate variability and change on rural household food security in Zambia with specific reference to Choma district. The district like the rest of the country is grappling with the effects of climate variation and change as well as other factors that affect crop production, in particular, luck of farming inputs such as fertilizer and seed. However, the approach used in this study associates the rural household food security situation in the district to climate variation and change and the investigation focuses on two climatic factors, mean annual rainfall and temperature.

The study was guided by one hypothesis which negated the existence of a significant relationship between climate variability and change, and the rural household food security situation in the district. Both primary and secondary data was used. In particular, primary data (through questionnaires) was collected from a sample survey of one hundred rural households taken from 23,356 rural households. Multi stage sampling was used to select both the study sites and the sampling units. On the other hand, secondary data in form of mean annual rainfall and temperature from 1976 – 2014 as well as while district level production of the staple (maize) for the same period was used. Trend analysis, multiple regression and frequencies were used to analyze these data.

The results show that mean annual temperature had increased during the period while mean annual rainfall was characterized by inter annual variability. On the other hand, the results show that the rural household food security situation was fluid (not static) and that 78 percent of the rural households had experienced food shortages while 22 percent did not. However, the study established that the climate variables used the study did not have a significant effect on production of the staple crop (maize) and accounted for only 12 percent of the variation in production. Based on these findings, the study concluded that mean annual temperature and rainfall were not the main determinants of the rural household food security situation in Choma district. To deal with this minimum contribution of climatic factors to food security, the study recommends that rural households begin to adopt other crops other than maize that can perform well under the prevailing climatic conditions.

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LIST OF ACRONYMS

AER	Agro Ecological Region
AIDS	Acquired Immune Deficiency Syndrome
CSO	Central Statistics Office
DFID	Department for International Development (United Kingdom)
DMMU	Disaster Management and Mitigation Unit (Zambia)
EPA	Environmental Protection Agency (United States of America)
FAO	Food and Agriculture Organization
GHG	Green House Gas
GRZ	Government of the Republic of Zambia
HIV	Human Immune Virus
IFPRI	International Food Policy Research Institute
IPCC	Inter Governmental panel on Climate Change
JAICAF	Japanese Association for International Collaboration of Agriculture and Forestry.
MOA	Ministry of Agriculture (Zambia)
MTENR	Ministry of Tourism, Environment and Natural Resources
SPSS	Statistical Package for Social Sciences
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WFP	World Food Program
ZVAC	Zambia Vulnerability Assessment Committee

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

Climate variability and change are perhaps the most serious environmental threats to the fight against food insecurity in Africa. This is because they affect food systems in several ways ranging from direct effects on crop production (e.g. changes in rainfall leading to drought or flooding, or warmer or cooler temperatures leading to changes in the length of growing season), to changes in markets, food prices and supply chain infrastructure. Specifically, they present an environmental threat to food security because of their impact on agricultural productivity. This is because almost all sectors of agriculture depend on weather and climate whose variability has meant that rural farmers encounter total failure (Ozor *et al*, 2010).

IPCC (2007) estimates that climate change will lead to increases in the frequency and intensity of natural disasters and extreme weather events, such as floods and droughts; changes in rainfall patterns with an expected reduction in agricultural productivity in already fragile areas, especially in sub-Saharan Africa. In view of this, WFP (2011) notes that these climatic changes threaten to significantly increase the number of people at risk of hunger and under nutrition.

Climate variability and change are expected to affect food security in several respects. This is because they have a direct, often adverse, influence on the quantity and quality of agricultural production (Akintola and Sowunmi, 2009). Because of this, IPCC (2007) predicts that by 2050, crop yields in Sub-Saharan Africa will have declined by 14% (rice), 22% (wheat) and 5% (maize) pushing the vast number of already poor, who depend on agriculture for their livelihoods, deeper into poverty and vulnerability. It also predicts decreased food availability by 500 calories less (a 21% decline) per person in 2050 and a further increase in the number of malnourished children by over 10 million - a total of 52 million in 2050 in Sub-Saharan Africa alone.

Zambia has been experiencing an increase in the frequency and intensity of extreme weather events. Recent studies indicate that temperatures in Zambia have been increasing especially over the last three decades (GRZ, 2007; World Bank, 2006; Jain, 2007; Ngoma, 2008, Shitumbanuma, 2008) while the country has experienced an increase in the frequency and intensity of droughts and floods. Sichingabula (1995) reported that the climate of Zambia has been characterized by epic dry and wet periods. Rainfall records show that Zambia experienced below and above average rainfall in the periods 1886 –1925 and 1926-1970, respectively (Sichingabula, 1998). In particular, the country experienced droughts in the seasons 1916/17, 1924/25, 1949/50, 1983/84, 1987/88, 1991/92, 1994/95 and 1997/98 (Sichingabula, 1998). Occurrence of droughts was also reported in the 2001/03 and 2004/05 seasons (Lekprichakul, 2008).

These extreme climatic events have had negative impacts not only on the Zambian economy at large, but also on small scale food production. According to Lekprichakul (2008), the economic impacts of droughts on Zambian have been evident, and he reports that the 2004/05 droughts led to a 60% loss of yields to maize which is the staple crop. This had an effect even on the next agricultural year when maize production recorded a drastic decrease of about 22% from the previous year. Furthermore, the CSO (2006) post-harvest report recorded that in the 2003/04 growing season, 1,134,319 tons of maize was produced compared to the 884,575 tons in 2004/05 season. This decline was attributed to drought effects experienced during the 2004/05 growing season. These declines in food production attributed to extreme weather events have had a great bearing on the household food security situation especially for the rural households.

It is noteworthy however, that there are many other factors which affect household food security for rural households other than climatic factors. These include government policy, distribution of inputs, transportation of produce and availability of markets for the produce. However, this study focused only on climatic factors. At the same time, it should also be noted that there are a number of climatic factors with potential to affect crop production and hence food security. However, this study only focused on mean annual rainfall and temperature. This is because, as argued by Akintola and Sowunmi (2009), temperature and rainfall among others, are important climatic elements that influence crop production and the overall predictability of these climatic elements is imperative for the day-to-day and medium term planning of farming operations. In this study, mean annual rainfall and temperature for the period 1976 to 2014 was assessed. For rural household food security, panel data on district annual production of the staple crop (maize) from 1976 to 2014 was also assessed including the period of household food shortage and households' perception of their food security situation. The study also looked at the strategies adopted by the rural households to moderate the food security effects of climate variability and change. In doing so, the study assessed climate change awareness among the rural households in the district as well as the adaptation and coping measures adopted to mitigate the food security effects of climate change and variability among the rural households.

1.2 Problem statement

Climate variability and change have become topical issues because of their effects on human lives and the future of the world. In particular, they affect food security. In Zambia, about 95 percent of rural households are occupied with crop production for subsistence as well as a source of income (Jain, 2007). They rely solely on rain fed agriculture for their food security, rendering them particularly vulnerable to variations in climate conditions and to predicted climate change (GRZ and UNDP, 2000).

There is a plethora of studies in the areas of climate variability and change in Zambia and with varying focus, among them; impacts on agriculture, (Jain 2007), perceptions of climate change (Kalinda, 2011), opportunities for adaptation and mitigation (Bwalya, 2010). In all these studies, the reality of climatic changes in the country has been well highlighted. However, there is still lack of studies that wholly focus on the link between climate variability and change, and rural livelihoods, in particular, link to rural household food security. In view of this, need arises to narrow down climate issues to the most vulnerable category, the rural households, and understand fully what the implications of climate variability and change are. With this state of affairs, accordingly, the present investigation focuses on what implications climate variability and change has on rural household food security. With climate variability and change increasingly becoming a reality, the exegesis of this concern is the understanding that rain fed agriculture is the backbone of rural household food security and majority of these lack the capacity, resources and financial assistance to adapt to and overcome the worsening climatic conditions.

The study further seeks to uncover the strategies that rural households have employed as remedy to the food security impacts of climate variability and change. The findings are critical in that they contribute to more targeted and effective policy and program options aimed at addressing the effects of climate variability and change on rural household food security.

1.3 Objectives of the study

The overall objective of this study was to establish the effects of climate variability and change on rural household food security in Choma district. This overall objective was dealt with using the following specific objectives:

1. To examine the climatic trends in Choma district from 1976 to 2014.

2. To establish the rural household food security situation in Choma district.

3. To establish the effect of the climatic situation on rural household food security in Choma district.

4. To determine climate change awareness among rural households in Choma district.

5. To identify coping and adaptation measures that rural households in Choma district are using to help mitigate potential effects of climate variability and change on food security.

1.4 Research questions

The general question for this study was: How does climate variability and change affect rural household food security in Choma district? In the effort of ensuring that the study comprehensively answers this question, the main question was subdivided into the following sub questions:

1. What climatic trends have been experienced in Choma district during the period 1976 - 2014?
2. How is the food security situation in Choma district?

3. What effect does the climatic situation has on rural household food security in Choma district?
4. Are the people in the rural households of Choma district aware of climate change?
5. How are the rural households of Choma district coping with and adapting to the food security effects of climate variability and change?

1.5 Research hypotheses

H_0: There is no significant relationship between climate variability and change and the food security situation in rural households of Choma district.

H_1: Alternative

1.6 Justification of the study

Bryant *et al*., (2000) and Smith *et al*., (2000) have argued that the impact of climate changes on crop production and food availability should be a priority area for governments around the world if food security is to be achieved. This is because climate variability and change directly affects agricultural production and therefore food security. This is primarily due to the fact that agriculture is inherently sensitive to climate conditions and is one of the most vulnerable sectors to the risks and impacts of global climate change (Parry *et al*., 1999). Therefore, for the Zambian government to come up with effective strategies and interventions in response to the food security effects of climate variability and change especially in rural areas, it is necessary to have information on how climate variability and change has affected rural household food security and this is what this study seeks to bring on board.

There is a dearth of studies in Zambia focusing on how climate variability and change has affected the rural household food security situation. The importance of the present study is that it will contribute to more targeted and effective policy and program options aimed at addressing this issue fully. In specific terms, it can be said that the study will inform policy on best strategies which can be replicated across the country to reduce the impact of climatic changes on food rural household food security.

In terms of the motivation behind carrying out this study in Choma district, the district was chosen for this study because of four reasons. Firstly, the district was chosen because it has been suffering from episodes of both dry and wet spells during the rainy season and these have sometimes been inter-annual. This situation is perceived to have affected production of the staple crop (maize) in the district, and hence the food security situation. Therefore the district was chosen so as to establish if at all these climatic changes had affected rural household food security. Secondly, the district falls in a high potential area, and has been described by MOA (2015) as among the four heavy weights in Maize production in the province. It should therefore be assumed to be food secure and yet many of the rural households suffer from food insecurity problems. Therefore, results of this study could be used to address food insecurity problems among the rural households in the district.

Furthermore, the district was chosen because it has had a number of researches tackling many different areas as opposed to other districts in the province. Therefore these previous studies came in handy in terms of providing information that was required to form the foundation of this study. Lastly, the researcher came from the area and this afforded the researcher the opportunity to also bring on board experiences on the topic which was important in enriching the output of such a study.

Lastly, the statistical analyses conducted in this study are limited to secondary climatic and production data for between the period 1976 and 2014. This period was chosen because it provided a time period adequate enough to effectively generate a case for climate change. It was also convenient for the reason that crop production data available through Crop Focust Surveys only date to 1970 when the country started conducting them, (Negassa *et al.*, 2000).

1.7 Scope of the study

The study of climate variability and change, and food security is a broad one and the variables that make this study tend to as well be loaded to fully exhaust them in such a study. Besides, climate variability and change have affected different areas differently hence making it inevitable that in such a study, one has to ensure localization of the variables that make the study. As a result, this study concentrated on the local climate variables that have been documented in the study area, and these are mainly changes in temperature and precipitation. Both of these elements been well documented and well understood. So it is around these two climate variables that the study concentrated on.

In addition, it is as well important to mention that the study area is predominantly a maize growing district in the country especially at the small scale level (household level) such that it falls in what has been termed the ‘Maize belt’ of the country. Other crops grown include sweet potatoes, groundnuts and garden vegetables. Some households keep cattle, goats and chickens. However, these are just meant to support the main food security determinant (maize). Therefore the major food crop or the staple crop grown in Choma district is maize and the rural livelihoods in the study area largely depend on this crop. In short, rural household food security in the study area is defined in terms of the staple crop, maize. Therefore, analyses of the food security situation in this study are limited to the maize crop, and this was further necessitated by readily available secondary data on the crop which provided a very good match to secondary data on climatic factors. The other reason for this choice is academic, in that it is allowed in food security studies to base the food security measurements on the staple crop. It should also be mentioned that for purposes of this study, households were considered food insecure if they could not meet 100 percent of their food requirement through production and food purchase.

1.8 Definition of Key Concepts

Climate variability

It is defined as the departure from normal or the difference in magnitude between climatic episodes (UNFCCC, 2012). In simpler terms, it can be said that variability is a measure of the frequency distribution of the value of climate variables and their range over a given time period.

Climate change

EPA (2004) defined climate change as any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer).

Climate change adaptation

Adaptation is defined as an adjustment of ecological, social, or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate the adverse impacts of change or take advantage of new opportunities, (IPCC, 2001).

Climate change coping

The UNFCCC (2012) defines it as actions taken to help communities and ecosystems cope with changing climate condition. It is responding to an experienced impact with a shorter term vision.

Food security

FAO (2002), defined food security as the situation when "all people, at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

Food systems

Food systems encompass activities related to the production of food; and the outcomes of these activities contributing to food security (FAO 2008).

Household food security

Bonti-Ankomah (2001) defined Household Food Security, as access by all households at all times to adequate, safe, and nutritious food for a healthy and productive life. For purposes of this study, households are considered food insecure if they cannot meet 100% of food requirement through production and food purchased and food production in this case refers to the amount of food in terms of cereals produced within the households in order to attain food security (Aluoko – Odingo, 2006).

Household

Piwoz (1985) defines a household as a unit of production, consumption and socialization feeding from family pot.

CHAPTER TWO
THE STUDY AREA

2.1 Introduction

This chapter focuses on the area where the study took place. It discusses the physical and socio-economic characteristics of the study area including; location, climate, physiographic characteristics, population, economic activities and land tenure.

2.2 Location

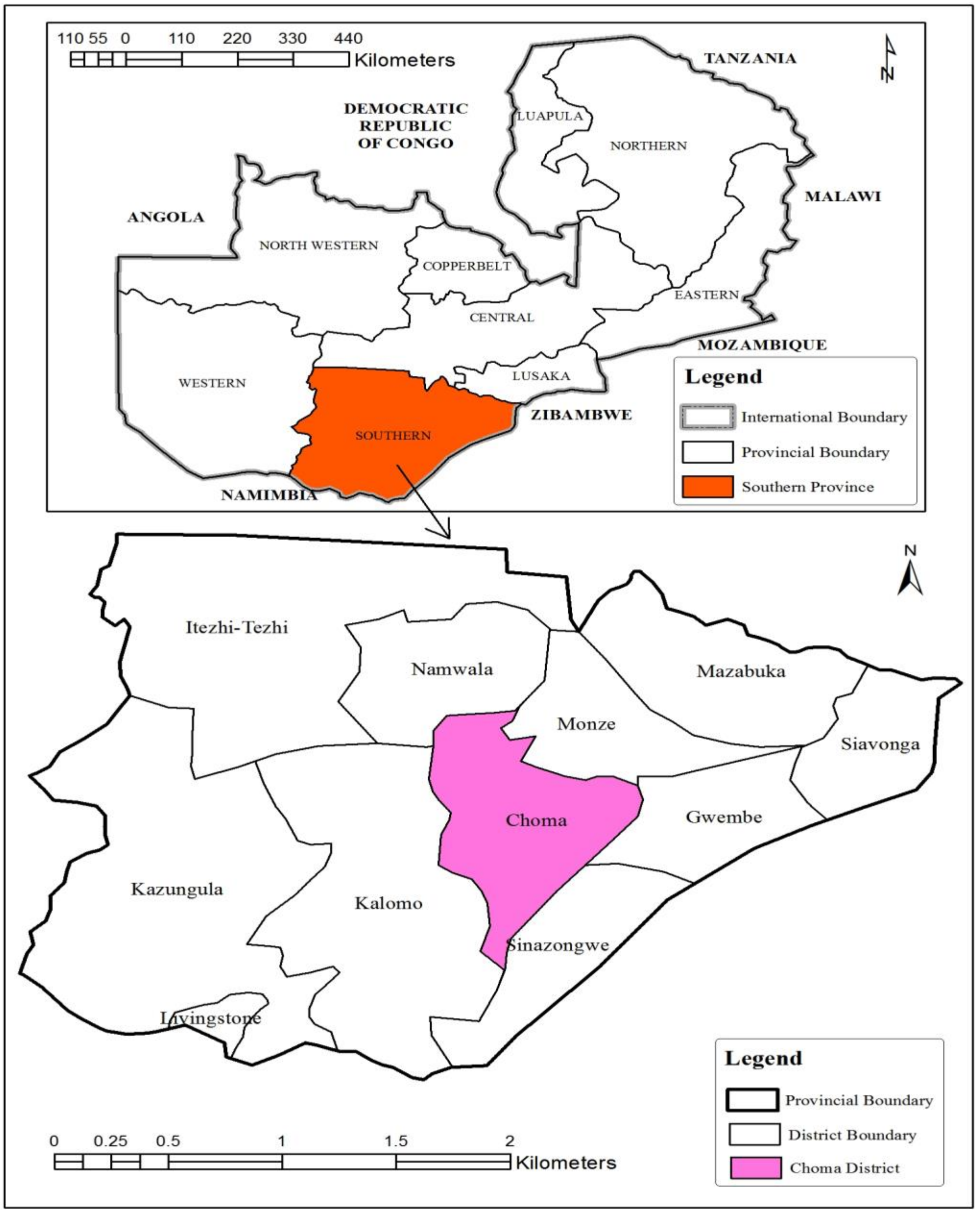
Choma District is in the Southern Province of Zambia and is located within the latitudes 16°50'S to 16º83'S and between longitudes 26º30' to 27°30' E as shown in figures 2.1 and 2.2. The district covers an area of 7, 296 km^2 and shares boundaries with five (5) districts, namely; Namwala to the north, Pemba to the northwest, Gwembe to the west, Kalomo to the south and Sinazongwe to the southeast. All the five districts are accessible from Choma owing to the existence of a railway line and a major road network as a means of communication. Choma District has five (5) traditional chiefs, namely; Singani, Mapanza, Macha, Hamaundu and Moyo. Each of these chiefdoms is further divided into wards which in some instances cover villages.

2.3 Climate

Generally, the Choma district falls in Agro Ecological Region (AER) II and specifically agro-ecological region IIa as shown in figure 2.3. Like most parts of Zambia, this agro ecological zone experiences tropical conditions that are moderated by altitude and rainy season that runs from October to April. The climatic conditions in the area are influenced by three (3) factors (GRZ, 2002):

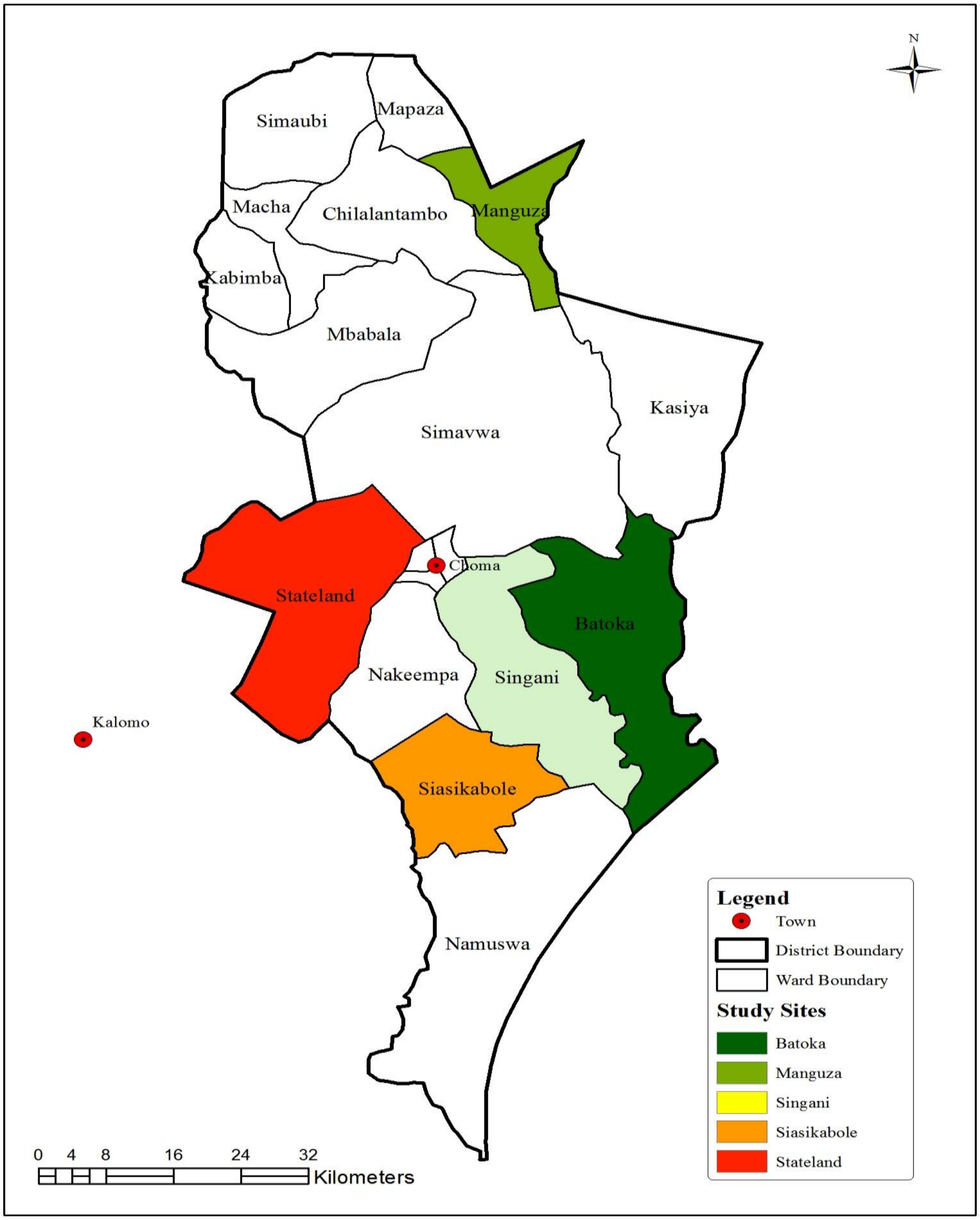
- Inter-tropical Convergence Zone (ITCZ); which results in Northern part of the country receiving more rainfall than the Southern part.
- Altitude; that causes low temperatures in the plateau areas
- EL Nino; which has been associated with particular droughts in Zambia. The 1992 drought was largely as a result of the El Nino in the Pacific Ocean.

Figure 2.1: Map showing Choma district in Southern Province



Source: Surveyor-General (1984)

Figure 2.2: Map showing the study sites (Wards)



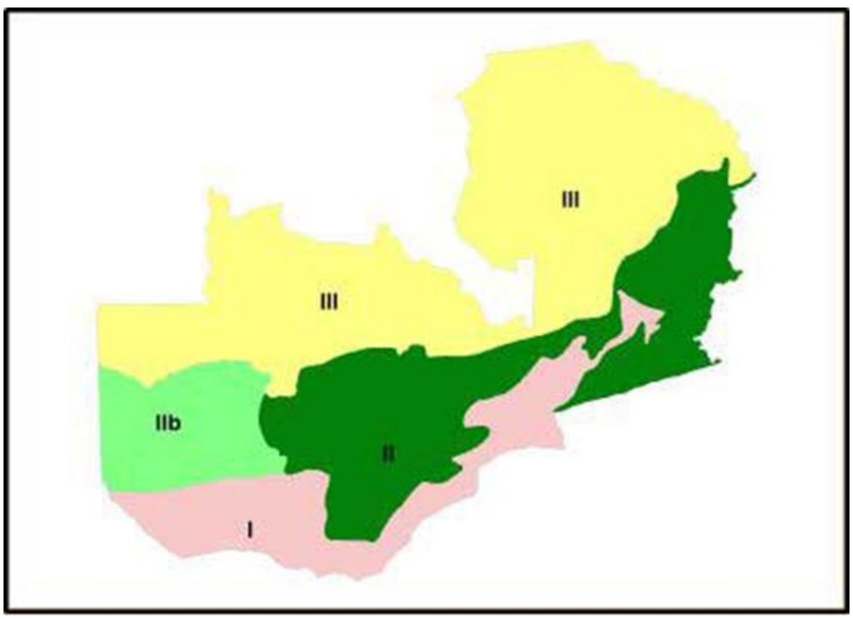
Source: Surveyor-General (1984)

Three (3) seasons can broadly be identified in the region:

- Warm wet season (November – April), with average temperatures of 27-30°C
- Cool dry season (May-July), with average temperatures of 16-27°C
- Hot dry season (August-October), with average temperatures of 27-30°C

Choma lies at approximately 1100m to 1300m altitude, in the so-called African surface (Dixey, 1955). In December, January and February rainfall exceeds potential evaporation with the surplus being 202mm. Thus, if the infiltration rate is too low to absorb heavy showers or the moisture storage capacity is too low to store infiltrated rain, there will be runoff. Initially, runoff is accompanied by the risk of erosion, then percolation with the risk of leaching.

Figure 2.3: Zambia's Agro-ecological regions



	KEY
Region	**Annual Rainfall**
I	Less than 800 mm
IIa	800 - 1000 mm
IIb	800 - 1000 mm
III	1000 - 1500 mm

Source: Jain (2007)

The rainy season in the district extends from October/November to March/April. July is the driest month with no rainfall. December and January are the wettest months with total seasonal rainfall of about 805mm. In specific terms Choma occurs in a zone of medium rainfall. The mean annual temperature is 18.3°C with daily temperature ranging from 12.6°C in July to 22.1°C in October. The mean daily maximum temperatures for the year is 26.6°C ranging from 22.7°C in June to 31.2°C in October. The mean daily minimum temperature for the year is 10.9°C with daily values ranging from 3.3°C in July to 16.5°C in December. The average hour of sunshine per year is 8.1 hours.

2.3.1 Agro – climatic conditions

Agro-ecological region II where Choma district lies covers the sandveld plateau zone of the Central, Eastern, Lusaka and Southern Provinces. The region has a growing season of 120 to 150 days and receives about 800mm to 1000mm of rainfall annually (GRZ, 2002; World Bank, 2006; Jain, 2007). It is the most productive region of the country. The region has a total area of 27.4 million hectares of which 87% (23.8 million hectares) could be used for agricultural purposes, but only 50% is actually accessible. The rest has been set aside for national parks, game management areas and forests (GRZ, 2007). Despite this, it has the highest agricultural potential in Zambia due to its fertile soils. Today, Eastern Province is the largest maize producer in Zambia, followed by the Southern and Central provinces (JAICAF, 2008) all located in AER II.

Agro-ecological region II and Choma district in particular has good yield potential for crops such as maize, sweet potatoes, sorghum, sunflower, groundnuts and tobacco. Therefore it supports agriculture of different crops such maize, sorghum, groundnuts, cow peas, and many others (Ngoma, 2008). Hence the highest maize producing districts in Zambia are found in AER II (JAICAF, 2008), and Choma is one of them.

2.4 Soils and Topography

2.4.1 Soils

Soils in Choma are brownish to reddish yellow with a fine texture. Around the drainage basins soils are usually dark in color and they are also sticky. The brownish yellow to reddish yellow soils is classified by FAO (1973) as haplic acrisols. The dark sticky soils around most drainage and flooded areas are referred to asvertisols. These soils are poorly drained and have a high available water capacity of between 80mm and 200mm. With good management these soils have a high potential for being ideal soils for grain cultivation.

2.4.2 Topography

The district falls within the larger AER II terrain which varies from hilly to flat. Aregheore (2006) reported that Zambia has three main topographical features: Mountains with altitude of at least 1500m; plateau with altitude ranging from 900m to 1500m; and lowlands with altitude ranging from 400m and 900m. The country is on the great plateau of Central Africa at an average altitude of 1200m though Advarneg Inc (2007) said that most landmass lies between 910m and 1370m above sea level. Part of this Great Central African Plateau lies in AER II where Choma district is located.

2.5 Drainage

Nkanga River, which is usually flooded during the rainy season, provides the main drainage systems in Choma town. It is on this stream that the Choma dam is constructed. The dam provides Choma residents with both domestic water and fishing grounds. Munzuma dam is also a source of domestic and even commercial water for Choma residents. Several other streams which rarely survive the dry season include: Kabwesha, Simanhwa, Munzuma and Nkanga.

2.6 Demographic Characteristics

Choma District houses 20 wards, split into two constituencies namely; Choma central and Mbabala. It is home to about 34,148 households (CSO, 2010). The distribution of this household population at constituency and ward level is shown in table 2.1.

Table 2.1: Distribution of households per Constituency and Ward:

CONSTITUENCY	WARD	HOUSEHOLDS
CHOMA CENTRAL	Batoka	1,260
	Sikalongo	1,455
	Simamvwa	2,106
	Stateland	1,355
	Moomba	771
	Nakeempa	976
	Kulundana	2,856
	Simacheche	1,959
	Sikalundu	1,966
	Mubula	4,491
	Singani	1,585
	Siasikabole	1,414
	Namuswa	2,127
	TOTAL	**24,321**
MBABALA	Simaubi	2,036
	Mapanza	984
	Mang'unza	992
	Chilalantambo	1,649
	Macha	1,328
	Kabimba	348
	Mbabala	2,490
	TOTAL	**9,827**

Source: Adapted from CSO (2010)

2.7 Socio-Economic Activities

Agriculture provides the major economic activity for people in AER II and Choma district in particular. The bulk of food and cash accruing to most people in the region is from maize being the most cultivated food crop. The District has approximately 180 commercial farmers, 150 emergent farmers and approximately 23,206 farming families who are involved in the production of cash crops or livestock. Primary crops include maize, tobacco, cotton and groundnuts; with primary livestock including cattle, goats, sheep, pigs and poultry. Agricultural production is oriented towards local needs and only small amounts of farmers' produce are sold on the markets. Some farmers are involved in mixed farming, vegetable gardening and trading. The Makalanguzu market, which is the main market, is well stocked with agricultural products, which are brought from surrounding areas.

In terms of the food security situation, Choma district, like most parts of the country is usually expected to have adequate staple food supply during the period of April to September. During this period, most farming households will access staple food and a variety of seasonal foods through own production, thereby increasing household food security. In addition, during this period, most households have access to staple food through labor exchange from the better off households and market purchases at reduced prices. After this period, most rural households run out of food stock as the harvests cannot go beyond and there are many factors behind this with climate change and variability being among them. In addition, prices of the staple (maize) begin to go up after this period further exacerbating the food insecurity situation for most rural households.

2.8 Land Tenure

Land at community levels continues to be under the state and the chief is a custodian /holds land for the benefit of community people. Families, clans or ethnic groups jointly own land under most indigenous communal or traditional lands and individual households are through Headpersons allocated portions of land that they hold in perpetuity. Inheritance of land is as in accordance with existing tribal /customary laws. The Lands Act of 1995 provides for ownership of land, including land under customary tenure through title deeds. Accordingly, individuals intending to convert customary land have obtained a letter of consent from the chief/chieftainess, and then take the letter to the local district council.

The typical average farm size for households in the study area is 2 hectares. In order to reduce vulnerability of rural society in Zambia and improve or rebuild resilience of food production, the Government of Zambia has continued to uphold the vision of empowering citizens with secure, fair and equitable access and control of land (Kajoba 2007). The National Land Policy currently in place advances the advantages of customary tenure practices in that it ensures government recognizes the rights of land users by defining these rights through formal survey and registration so that everyone irrespective of social status, gender and origin has similar rights to land. It can therefore be said that the land practices available in terms of tenure are structured in a manner aimed at promoting production and enhancing rural household food security.

CHAPTER THREE
LITERATURE REVIEW

3.1 Introduction

The purpose of this review is to explore existing literature as pertains to the climate variability and change; globally, at continental level, regional and country level. The review also explores the linkages between climate variability and change, and household food security, with focus on how climatic factors impact adversely the food security situation of households. The review also focuses on the food security situation in Zambia and provides adaptation strategies available as well as existing empirical studies in the field.

3.2 Climate Variability and Change

Climate variability and change are the most important environmental challenges facing the world today. According to Hougton (2002), climate change is possibly the greatest environmental challenge facing the world this century. This has been supported by a spate of conferences, campaigns, reports and research work on climate change over the past 20 years (Agenda 21 of Rio declaration, 1992; IPCC, 2001a) just to mention but a few.

It has been agreed by the majority of scientists that climate change and variability are mainly driven by the emission of GHGs, such as carbon dioxide, methane and nitrous oxide (IPCC, 2007a). Although there are other sources of emissions, agriculture is one of the most important contributors of emissions of GHGs and the sector is increasingly being recognized for its potential to be part of the solution (IPCC, 2007a). According to Smith (2008) energy and chemical intensive farming has led to increased levels of GHG emissions, primarily as a result of the land clearance, soil degradation and intensive animal farming. Observed effects of climate change and variability have been documented in the IPCC assessment reports. For example, there is extensive evidence of responses of cryosphere components; such as mountain glaciers and ice caps, floating ice shelves and continental ice sheets, seasonal snow cover on land, frozen ground, sea ice and lake and river ice; in the form of reduction of snow and ice masses due to enhanced warming (Rosenzweig *et al* 2007). Biological systems have also gone through changes due to shifting climate. These include shifts in plant and animal ranges pole-ward and higher elevation; reductions and increases within population sizes of some animals and plants; changes in life cycle events, such as blooming, migration and insect emergence; and effects on changes in species at different speeds and different directions causing a decoupling of species interactions, for instance predator-prey relationships.

3.2.1 Climate variability and change – Global perspective

Research shows that the earth has become warmer during the previous century. The Intergovernmental Panel on Climate Change (IPCC, 2001) reports that the average surface temperature of the earth has increased during the 20th century by about 0.6°C ± 0.2°C, (the ± 0.2°C means that the increase might be as small as 0.4 °C or as great as 0.8°C). The IPCC has further reported that it is warmer today around the world than at any time during the past 1000 years. In addition, extreme weather events are now on the rise worldwide and are more likely to happen in the future (Easterling *et al*., 2000).

Therefore, it is clear that the earth is warming and the serious doubts over this fact and that the human emissions of greenhouse gases such as carbon dioxide (CO_2) as the primary cause of it are disappearing in the face of mounting evidence from around the world (Lobell and Burke 2010). Global and regional shifting of climate patterns and their potential effects on the biophysical and human systems has become an important topic over the recent decades. It is widely argued by most climate scientists, a large number of academic and nonacademic international institutions, as well as many well-known politicians that the bulk of the changes resulting from global climate change are, and will be, adverse in nature.

3.2.2 Climate variability and change in Africa

Since the IPCC third Assessment Report on climate Change, IPCC (2001), observed temperatures have indicated a greater warming trend since the 1960s. Although these trends seem to be consistent over the continent, the changes are not always uniform. For instance, decadal warming rates of 0.29°C in the African tropical forests (Malhi & Wright, 2004) and 0.1 to 0.3°C in South Africa (Kruger & Shongwe, 2004) have been observed.

Climate change can also be observed in the form of precipitation. For precipitation, the situation is more complicated. Rainfall exhibits notable spatial and temporal variability (Hulme *et al*., 2005). Inter annual rainfall variability is large over most of Africa and, for some regions; multi-decadal variability is also substantial (IPCC, 2007). In West Africa, a decline in annual rainfall has been observed since the end of the 1960s, with a decrease of 20 to 40 percent noted between the periods 1931 to 1960 and 1968 to 1990 (Nicholson *et al*., 2000; Chappell and Agnew, 2004; Dai *et al*., 2004). In the tropical rain-forest zone, declines in mean annual precipitation of around 4 percent in West Africa, 3 percent in North Congo and 2 percent in south Congo for the period 1960 to 1998 have been noted (Malhi and Wright, 2004). A 10 percent increase in annual rainfall along the Guinean coast during the past 30 years has, however, also been observed (Nicholson *et al*., 2000). In other regions, such as southern Africa, no long-term trend has been noted. Increased inter-annual variability has, however, been observed in the post-1970 period, with higher rainfall anomalies and more intense and widespread droughts reported (e.g., Richard *et al*., 2001; Fauchereau *et al*., 2003).

3.2.3 Climate variability and change in Southern Africa

The warming trend observed in southern Africa over the last few decades is consistent with the global trend of temperature rise in the 1970s, 1980s and particularly in the 1990s. According to the IPCC (2001), temperatures in the region have risen by over 0.5° C over the last 100 years. For example, between 1950 and 2000, Namibia experienced warming at a rate of 0.023° C per year (Government of Namibia, 2002). The Indian Ocean on the east coast has also warmed more than 1°C since 1950, a period that has also witnessed a downward trend in rainfall (NCAR, 2005). Below-normal rainfall years are becoming more and more frequent and the departure of these years from the long-term normal, more severe (USAID, 1992).

According to Cull and Vincent (2004), between 1988 and 1992, over 15 drought events were reported in various areas of southern Africa. There has also been an increase in the frequency and intensity of El Niño episodes. Prior to the 1980s, strong El Niños occurred on average every 10 to 20 years. However, the early 1980s marked the beginning of a series of strong El Niño events: 1982/1983; 1991/1992; 1994/1995; and 1997/1998. The episodes of 1982/1983 and of 1997/1998 were the most intense in the last century. Paradoxically though, the 1991/1992 El Niño, which was considered as a moderate event, caused a major drought throughout southern Africa.

3.2.4 Climate variability and change in Zambia

Over the last three decades, the frequency of extreme climate events such as high surface temperatures, floods and droughts has increased over the entire globe and Zambia in particular. Although such extreme events are attributed to climate variability, they also signal that the country is going through long-term climate changes in mean temperature and rainfall norms. The country for instance experienced worse drought in 1992/93 while the wettest conditions were recorded in 1978/79. Within the past years the country has experienced droughts, floods and normal conditions with the frequency of occurrence of drought and floods and their intensity and magnitude being on the higher side.

Zambia has experienced an increase in drought frequency and intensity in the last 20 years. Sichingabula (1998) contended that droughts in Zambia occurred every year as there was always a part of the country experiencing below normal rainfall. The probability of drought occurrence was lowest in the wettest northeastern area (34%) and highest in the driest southwestern area (66%). In addition, the rate of drought occurrence in Zambia has been increasing over the past decades. Fewer droughts were recorded in Zambia between 1976 and 1988 but between 1989 and 2002 there was an increase in drought frequency.

The recent extreme event in relation to floods occurred in the 2007/08 rainy season, affecting a wide geographical area in the country (ZVAC, 2008). Between the years 2002 and 2007, Zambia experienced two major floods (2002/3 and 2006/7) (GRZ, 2007). The country further experienced massive flooding in the years 2008/9 and 2009/10. DMMU (2007) (in GRZ, 2007) reported that the 2007 floods affected 41 out of 72 districts in Zambia which included areas never before affected by flooding. Historical data proves that recent floods have been more widespread and more frequent and in some years too early in areas where they are expected late.

Table 3.1: Selected Impacts of climate variability in Zambia (1972—2008)

SEASON	SELECTED SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS
1972/73	Poorest rainy season in 50 years; drought caused substantial drop in crop yields and a reduction in groundwater reservoirs
1977/78	Heavy rainfall resulting in urban flooding in Lusaka (Kanyama disaster –extensive infrastructure and settlement damages). This resulted in considerable damage to agricultural crops in many parts of the country.
1978/79	A drought rainy season, reducing maize production by 25 – 40 percent
1979/80	A poor rainfall distributed rainy season with elongated dry spells. This caused considerable losses to the 1980 maize crop in Southern Province.
1981/82	Below normal rainfall caused reductions in crop production as well as livestock production. Rainfall deficits ranged from 30 to 50 % in Southern & Western and 10 to 40 % elsewhere. The Luano Valley of Central Province experienced significant famine.
1982/83	Frequent dry spells during the season led to poor performance in the agricultural sector, especially over the southern half of Zambia
1983/84	Drought reduced agricultural yields for the third consecutive season; worst affected areas were Southern, Central and Western Provinces
1986/87	Frequent dry spells between February and

	March led to widespread crop failure in Southern Province.
1988/89	Heavy rains in mid-season caused extensive water logging in crop fields; around Lusaka many people whose houses collapsed were left homeless and lost other household property.
1989/90	Persistent dry spell caused severe moisture stress in the major maize growing areas of Southern, Central and Eastern Provinces.
1990/91	Southern, Central and Lusaka Provinces experienced dry weather conditions. Marketed maize was only 46 % of annual requirement.
1991/92	Worst drought for many years hit the most critical crop stage (silk formation). All areas were declared disaster areas by the then Republican President, F.T.J. Chiluba.
1999/2000	Heavy rainfall caused floods in many parts of the country. (Season of "Mozambique" Floods).
2005/06	Heavy rainfall resulted in flash floods especially in the lower Zambezi (Kazungula floods, Kafue Gorge mudslide resulting in country wide ZESCO black out).
2007/08	Excessive rains over much of the country resulting in flash floods.

Source: Adapted from Kanyanga (2008).

These climatic scenarios which the country has been experiencing represent significant departures from average state of the climate system (Kanyanga, 2008). These climatic hazards are associated with human-induced climate change and natural climate variability. The climatic indicators have shown that the country has experienced an increase in temperature and a decrease in rainfall over the past decades. Studies have revealed that over the past three decades temperature has been increasing at 0.6^0C per decade. There has also been an increase in the occurrence of extreme events along with their intensity and magnitude. The most serious ones have been drought, seasonal floods and flush floods, extreme temperatures and dry spells (MTENR, 2007).

The climatic patterns elaborated in these studies are indicative of the effects of climate variability and change. The effects have adversely and immensely impacted on the Zambian population at all levels and virtually on all sectors of the economy, including on the natural and the built environment. Notably, all the sectors of the economy are vulnerable to climate variability and change with the most affected being agriculture, water, wildlife, forestry, health and energy. As pointed out by (ZVAC, 2008), food and water security, water quality, energy and the sustainable livelihoods of rural communities are some of the areas that have been adversely affected and this has subsequently threatened the accessibility of vulnerable Zambians to adequate food, good health, safe and adequate water supply and sanitation and sustainable livelihoods in general. The evident impact of droughts and floods led to a significant decrease in the productivity of primary sectors like agriculture, fisheries, wildlife and tourism (MTENR, 2007).

3.3 Climate variability and change, and food security - the linkages

The issue of food security is directly linked to climate change (Winters *et al*., 1999; Reilly, 1995). Climate variability with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID 2004; Kinuthia, 1997). According to DFID (2004) climate change will result in Northern and Southern latitudes getting drier while the tropics are expected to become wetter. Moreover, climate variability is expected to increase the frequency and intensity of extreme weather conditions in Africa. The implications for southern Africa for example, are that the region would generally get drier and experience more extreme weather conditions, particularly droughts and floods, although there would be variations within the region with some countries experiencing wetter than average climate.

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

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

Agricultural production remains the main source of livelihood for most rural communities in developing countries and sub-Saharan Africa in particular. Here, agriculture provides a source of employment for more than 60 percent of the population and contributes about 30 percent of Gross Domestic Product (Kandlinkar and Risbey, 2000). Climate change will have greater negative conditions. So it is very clear that in the face of climate change, food security is likely to be the major challenge for the rural households whose livelihoods entirely depend on agriculture.

In Africa, low levels of food security and economic development conspire with high levels of climate risk (FAO, 2012). Warmer temperatures affect crops and crop production, and changes in rainfall patterns are as important. Climate change also influences the availability of water for human consumption and for food production (Walter, 2007). Climate change represents an immediate and unprecedented threat to the food security of hundreds of millions of people who depend on small-scale agriculture for their livelihoods. In many African countries and regions, food security is likely to be severely compromised by climate change and climate variability (Boko *et al*., 2007). By the 2080s, climate change is estimated to place an additional 80–120 million people at risk of hunger, and 70–80% of these will be in Africa (Parry *et al*., 2004).

3.4 Climate change, variability and the components of food security

3.4.1 Impact of climate variability and change on food availability

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

In addition, the consensus of scientific opinion is that countries in the high temperate and mid-latitude regions are generally likely to enjoy increased agricultural production, whereas countries in tropical and subtropical regions are likely to suffer agricultural losses as a result of climate change in coming decades (Arnell *et al*., 2002; Devereux and Edwards, 2004). It should be noted that the favorable assessment for temperate and high latitude regions is based primarily on analyses of changes in mean temperature and rainfall; relatively little analysis done to date takes account of changes in variability and extremes. Impact of climate variability on crop production should be a priority given that analyses of agricultural vulnerability indicate that the key attributes of climate change are those related to climatic variability, including the frequency of non-normal conditions (Bryant *et al*., 2000 and Smit *et al*., 2000).

3.4.2 Impact of climate variability and change on food access

Individuals have sufficient access to food when they have "adequate incomes or other resources to purchase or barter to obtain levels of appropriate foods needed to maintain consumption of an adequate diet/nutrition level" (USAID, 1992). Food access depends on the ability of households to obtain food from purchases, gathering, current production, or stocks, or through food transfers from relatives, members of the community, the government, or donors. Intra-household distribution of these resources is an important determinant of food security for all household members. Food access is also influenced by the aggregate availability of food in the market, market prices, productive inputs, and credit (USAID, 1992). Poor market infrastructure and an unfavorable policy environment may lead to high and variable prices for food and inputs, further undermining agricultural productivity, food supplies and derived incomes.

Access depends on the physical factors, as well as social and economic factors. After food is produced, it needs to be moved from the point of production to the point of consumption. This often depends on transport systems. In many developing countries, inefficient and ineffective transport systems retard the delivery and increase the price of food. Climate change is expected to place a strain on transport systems (IPCC, 2001a). For example, increased heat stress may reduce the life of roads, and windstorms can impact transit at air and sea port terminals as well as damaging infrastructure which may create delays (Perry and Symons, 1994). During droughts, people are known to move into marginal lands. Most of these marginal lands may not have good road access, and transporting food from such marginal farms poses a huge challenge.

3.4.3 Impact of climate variability and change on food utilization

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

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

3.4.4 Impact of climate variability and change on food stability

Although much scientific attention has been paid to the availability of food through modeling, relatively less is known about the stability of food supplies and its effect on food security (Vincent and Cull, 2010). The stability element of food security is about adequacy of food supplies "at all times" and to the potential for losing access to the resources needed to consume adequate food, since even a temporary disruption to food supplies or access can have fatal consequences. This may occur, for example, through failing to insure against income shocks or lacking the reserves to compensate for such shocks.

Weather extremes and climate variability are the main drivers of food production instability, especially in rain-fed farming systems with limited irrigation. There remains little analysis of the impact of the changing frequency of extreme weather events on stability, particularly the interaction at the local level between relatively moderate impacts of climate change on overall agro ecological conditions and much more severe climatic and economic vulnerability (Easterling *et al.*, 2007). Already many areas, such as southern Africa, are accustomed to unpredictable and unstable harvests based on inter-annual climate variability, but even for these places the pace and projected levels of warming may expand, and rising frequency and intensity of extreme events such as droughts is likely to increase the instability of food production.

3.5 Food security situation in Zambia

Zambia's food security situation is serious despite the occasional surpluses the country produces during good crop years. Whichever measure of food security one uses, Zambia is no longer able to feed itself. As a result, chronic malnutrition (stunting) has affected about 45 to 47 percent of the rural households, whilst malnutrition (wasting) has inflicted about 6 percent of all rural households, (Kalinda *et al*, 2001). Therefore, the children affected with chronic malnutrition will remain physically and/mentally impaired for life, even if they survive. This high rate of malnutrition has serious implications on Zambian's development prospects.

The main sources of Zambia's food insecurity at household level are an inability to produce enough food due to lack of agricultural service support and technical exigencies such as unfavorable climatic conditions, disease and insect attacks, etc; inadequate incomes and inability to purchase food; inadequate market and transport systems to take food from surplus to deficit areas within the country; and the impact of HIV/AIDS on the productive capacity of households (Kalinda *et al*, 2001). The detrimental impact that HIV/AIDS may have on rural households' productive capacity and food security has been experienced in some of Zambia's rural communities.

3.6 Climate change awareness

Every day people make decisions in different areas of agriculture and climate change is becoming an increasingly important factor in more and more of these decisions. Climate change awareness needs to be practical in nature and help farming households to deal with productivity and to be able to make decisions that are aligned both with the most reliable available information and their own ethical values. Several research studies have been conducted in various places across the globe to know and determine the level of awareness of people, especially in agriculture and farming activities.

Many people claim to be aware of climate change but in actual fact they are not really aware. Aphunu *et al*. (2012) indicated that, although farmers were aware of the phenomenon, their level of knowledge about the impact of climate change was low. The farmers indicated relying mostly on personal experience rather than on the mass media or extension agents as their main source of information. According to Olayinka *et al.* (2013) despite the fact that the majority indicated various levels of awareness, their understanding of the phenomenon and consequences varied significantly while their knowledge about the causes was generally low.

The Niger Delta region of Nigeria is known to be susceptible to climate change impacts because of its fragile ecosystem and human activities such as gas flaring. A study by Thaddeus *et al*. (2011) indicated that although there is a high level of awareness of climate change in the region, knowledge of Niger Delta farmers on the adverse effects of the changing climate leaves much to be desired. In fact, as much as 60 percent of farmers in this study were found to know little or nothing about climate change and its impacts. Knowledge of climate change impacts is related to availability and accessibility of information on the phenomenon. In another research conducted on the awareness of climate change on cocoa production in Ghana, it was established that all cocoa farmers (100 percent) irrespective of their geographical locations were aware about climate change and its multitudinous effect on their farming activities (Francis *et al*., 2013). When it comes to climate change, many people are already aware of the existence of climate change, and at the same time, they are aware of the impact of climate change.

Another study conducted by Sujit and Padaria (2010) in India, showed mixed type of result about awareness level of people in relation to climate change. Though some people were fully aware of climate change, but majority of them lacked detailed information about climate change. However, there is a need for assessment among farmers on climate change. Henry (2001) proposed that there is a need for educational campaigns to target females, the poor and the illiterate given that gender, education and income were positive and significant in people's awareness of the importance of climate change. He further argued that agricultural extension officers can play an important role in educating the farmers about climate change, mitigation and adaptation. There is need for African nations to include the climate change issue as a vital component of long-term policy and planning, particularly in terms of education and awareness in order that it may be fully appreciated by the general public.

3.7 Rural community adaptation strategies to climate induced food insecurity

Adaptation remains a key factor in the battle against climate change and variability. According to Thompson *et al*, (2010), adaptation responses can be in response to the three dynamics of food security, which are food availability, access, and adequacy. Rural communities in the developing world are at risk of climate change and adaptation is a necessity (Boko et al. 2007; Smit and Wandel 2006; Parry, 2009).

It is argued that the negative effects of climate variability and change can be reduced if effective adaptation strategies are implemented (Kurukulasuriya and Rosenthal 2003; Poonyth *et al*. 2002; Mendelsohn et al., 1994; Rosenzweig and Parry 1994). For example, varieties with a short vegetation cycle and the timing for an effective season have been reported as effective measures adopted by farmers in Africa (Yabi and Afouda 2007). Breeding plants for tolerance to drought, heat stress, salinity, and flooding will become increasingly important (FAO 2008). Moreover, cropping systems moved from locations where the climate has become unsuitable to locations that have become more favorable have also been observed (Ingram *et al*., 2008).

3.7.1 Global adaptation strategies

Along with discussion of the mechanisms by which climate change impacts food security, adaptation strategies have been proposed in the literature. In relation to food availability, extensification and intensification are the major options documented to improve crop yields. One estimate suggests that extensification could increase cereal production in Africa to 47 percent by 2020 (Thompson *et al*, 2010). It also has implications however, for generating further environmental degradation, with land coverage changes and deforestation found to contribute to carbon dioxide emissions. Generally, intensification of agricultural land is seen as the most viable solution. This would require improving the quality of soil and maximizing usage of water resources, which often require greater inputs.

Edwards (2007) argues for the benefits of organic agriculture, whereby compost is used as a natural fertilizer. Projects in Ethiopia have shown much higher yields, both in comparison with no inputs and with chemical fertilizers. Manure is also seen as an input that could improve soil quality, and thus permit intensification. There remains debate, however, as to the potential for organic fertilizers to meet demands in soil fertility, and a more traditional approach has been the promotion of chemical fertilizers. While very common and quite heavily used in the developed world, these are relatively absent in especially in Africa. While valuable for improved agricultural yields, increased use of fertilizer may also contribute to climate forcing through the introduction of increased nitrous oxide emissions from soils.

With water shortages expected to occur alongside climate change, maximization of water resources is an additional concern, especially for intensification to become successful. Crop irrigation has seen some success, and it is argued by some that it should be more widely implemented. Others however, highlight the limitations of subsistence farmers, and suggest that small-scale and affordable solutions would be more beneficial Thomson *et al* (2010).

To better take advantage of limited water resources, certain crop varieties are also identified as important components of adaptation strategies. According to Thompson *et al*, Genetic modification is one possibility, in terms of the creation of drought-resistant or high-heat tolerance crop varieties. High-yielding seeds are additionally seen as a possibility to increase crop productivity. Furthermore, certain crop varieties have been identified and classified as ―underutilized, based on their potential value as being both highly productive in poor soil conditions and nutritionally beneficial. Further research is recommended to identify additional underutilized crops.

Another adaptive strategy for improving crop yield is modifying agricultural practices more directly. Thompson *et al,* further argue that crop diversification is one possibility, whereby dual-land use agricultural systems may be used to grow some of the more staple crops for a specific region, along with an insurance crop in case of crop failure. This would reduce food insecurity, whereby there is always at least one crop to fall back on. No-tillage farming is additionally seen as less disruptive to the soil, helping to maintain soil nutrients and water availability.

In terms of *accessibility*, the primary adaptive strategy to minimize vulnerability of financial capital, and thus improve market access when subsistence crops are not plentiful enough to provide food security, is livelihood diversification. This is believed to allow for sources of income that are not fully reliant upon the natural environment, and thus less vulnerable to climate change. Off-farm employment is considered particularly viable for youth, who could earn money to send back to their families. Physical market accessibility remains a challenge with respect to general improvements in urban, rural, and transportation infrastructure.

Adaptive strategies related to the *utilization* component of food security are mostly implicit in discussion of certain underutilized crops, and their nutritional value. Groundnut for instance is seen as a rich source of protein and energy. *Pigenopea* is also identified as high protein, a rich source of carbohydrates, and an important source of various vitamins and minerals. Access to information about climatic changes and potential adaptive strategies, in order to effectively promote practical adaptation, must also be provided to those subsistence farmers who will be most affected. In many cases, existing recommendations for improved farming practices are already consistent with increased adaptive capacity to projected climate changes. Additional awareness among farmers that unfavorable climatic conditions are likely to become more common can further mitigate the danger that subsistence farmers will fall back on traditional coping strategies that may be maladaptive in light of climate change; with decreased opportunity to recover, adaptive capacity may be limited (Edwards, 2007).

3.7.2 Africa and Zambia - adaptation strategies

The impact of climate change and variability on food security has been identified as a major area of concern given marginal climatic conditions in many parts of Africa, subsistence livelihoods, and limited resources for adaptation. In particular, the predominance of rain-fed agriculture in much of Sub-Saharan African results in food systems that are highly sensitive to rainfall variability.

Across Sub-Saharan Africa, communities have extensive experience in dealing with climatic uncertainties and food security implications. Subsistence livelihoods have evolved a number of coping mechanisms to manage weather variability, including drought years and low crop yield. Commonalities in coping are evident across diverse regions, involving a complex hierarchical decision-making process of sacrifice and use of support networks to endure periods of food insecurity. These strategies initially involve responses including alterations to diet to include more famine foods, and during times of acute and/or prolonged stress borrowing from kin, selling productive assets, and eventually migration. As famine progresses, survival strategies thus become more desperate, whereby domestic resources are increasingly committed and potential for reversing the strategies become more constrained.

According to Ngigi (2009), the beginning of water shortages in some areas has impelled for more efficient use of water through drip irrigation and the choice of high yielding and high-value crops (Ngigi, 2009). The use of drought-resistant crop varieties and the improvement of on-farm irrigation efficiency using better water application technologies are all methods that have been tried by smallholder farmers as adaptation methods to climate change in Nigeria, Senegal, Burkina Faso, and Ghana (Ngigi, 2009).

3.8 Empirical studies

A lot of studies globally have been undertaken and have confirmed that Climate variability and change have adverse impacts on food security. Schmidhuber and Tubiello (2007) argued that with an increase in frequency and severity of the extreme events such as cyclones, floods, hailstorms, and droughts, global and regional weather conditions are also expected to become more variable than at the present time. According to them, this will result in greater fluctuations in crop yields and local food supplies and higher risk of landslides and erosion damages, therefore adversely affecting the stability of food supplies. According to Bruinsma (2003), the majority of areas where such effects will likely be felt is in sub-Saharan Africa and parts of South Asia. This points towards the fact that the poorest regions with highest level of chronic undernourishment will also be exposed to the highest degree of instability in food production thereby exacerbating the problem.

A study by Nelson *et al* (2008) reviews that nearly half (2.5 billion) of the economically active population of the developing countries relied on agriculture for its livelihood in 2005. This research shows that due to climate change, most important crops will have a decline in their yields, particularly in South Asia. Additionally, it will result in price increases for rice, wheat maize, and soybeans leading to higher meat prices. By 2050, calorie availability will decline relative to 2000 levels throughout the developing world. This will increase child malnutrition by

20 percent relative to a world with no climate change. Much of the improvements in child malnourishment levels in a no-climate-change scenario will also be eliminated.

In a study of rural Afghanistan communities, Mihran (2011) concluded that failure of agriculture to produce reliably and sufficiently for households to meet domestic consumption needs and/or surplus for meeting households' other basic needs affects food security in all its forms. This study indicated the existence of food insecurity in the rural communities throughout the country as a result of the impacts of climate change and variability. Reduced agricultural productivity resulting from climate change affected food availability in the local and regional markets as well as within the subsistence-farming households. One very important point raised in this study is that this situation combined with poverty and widespread unemployment, would also mean lower family incomes and inability to afford sufficient food to meet dietary needs. However, the study presents a unique environment in that the effects of climate change and variability have been compounded by the conflict in Afghanistan.

Akudugu *et al* (2012) in a study of rural households in Northern Ghana revealed that communities which hitherto never experienced the double tragedy of drought and floods within and between seasons are now experiencing it. According to this study, the direct impact of climate change on agriculture was making most households who depend on it for their livelihoods food insecure. This is because of the fact that agriculture is vulnerable to external shocks including economic crises, and food price increases and emergencies such as droughts, floods, pests and diseases outbreaks. Food security is more difficult to achieve in northern Ghana under climate change regimes as vulnerability to drought and floods continue to bring chronic or periodic food and nutrition insecurity. Guaranteeing the availability, accessibility and stability of food supplies is affected by the changing patterns in crops cycles impacted by climate change. It was also found that food insecurity at the household level triggered by climate change negatively impacts on general livelihoods and thus has the potential to put families permanently poor or trapped in the poverty cycle.

In Kenya, a study conducted by Kabubo-Mariara and Kabara (2014) also reviewed very interesting results. Their study suggests that high rainfall is crucial for increased crop productivity and thus food security, but excessive rainfall is harmful. According to this study, this is because flooding and water logging destroys crops at the formative periods, while heavy rains during the harvest season lead to rotting of mature crop. Their results support literature that has found a non-linear relationship between temperature and precipitation on agricultural production (Mendelsohn *et al*. 1994, 2003; Kurukulasuriya & Mendelsohn, 2008; Kabubo-Mariara & Karanja, 2007). Short rains runoff is associated with higher yields, while long rains runoff is associated with lower yields. Earlier studies found a non-linear relationship between hydrological factors and crop revenue (Kabubo-Mariara and Karanja, 2007). This study though, derived its conclusions from one component of food security and the single variable used was food availability.

Another study by Belloumi (2014), revealed results not different from other studies. This paper analyzed the effect of climate variables on food security indicators from 1961-2011 for 10 Eastern and Southern African countries. The author used three indicators of food security: food production index, mortality rate of children under five years of age, and life expectancy at birth. The results showed that precipitation and temperature can negatively affect food security in East and southern African countries. The decrease and variability of rainfall coupled with the continuing rise in temperature according to this study will reduce food production and increase the percentage of the total undernourished population.

In Zambia, a study by Jain (2007), established that crop production in the country had faced negative impacts of extreme climate events which are believed to be manifestations of long term climate change. Zambia has experienced some of its worst droughts and floods in the last two decades. This study established that significant rainfall deficits at critical stages had been experienced as most areas had continued to receive below normal rainfall.

Contrary to all these studies, a study by Obasi and Uwanekwu (2015) which investigated the effects of climate change on maize production in Nigeria revealed that climate change significantly affected the productivity of maize crop in Nigeria. The study found that as temperature and rainfall increased, there were increases in output and of maize which may have been induced by climate change. Due to this, the study concluded that climate variability is an important determinant resource for crop production in Nigeria, very important to agriculture in Nigeria.

3.8.1 Measuring food security

There is no conventionally exact, “gold standard” measure of food security and different alternative measures are used in its assessment. Food security is recognized as a multifaceted condition of complex causality that is related to, yet distinct from, poverty and hunger. Given its broad definition, it is no surprise that food security eludes precise measurement. While accurate measurement of household food security is essential for effective research and well-targeted policies and programs, there is no standard methodology for measuring food security, and despite an improved theoretical understanding of food security, the FAO notes that there exists no perfect single measure that captures all its aspects (FAO, 2002). The absence of such a 'gold standard' makes it unreasonable to use a single benchmark to proxy food security. In light of its multidimensional nature, it is generally agreed that a suite of indicators and methods are needed for the assessment of food security.

According to Barrett (2010), the choice among indicators involves tradeoffs and the underlying purpose of a research commonly determines the choice of indicators. In view of that, some studies such as Bekele (2013) employed multiple indicators in investigating the household food security situation in the Borana area. Others such as Wineman (2014) developed a relatively simple measure of food security in the form of a single composite index that incorporates indicators of multiple dimensions. This composite index was applied to households from rural Zambia to address the following questions: Where are food insecure households found within Zambia? What is the nature of the food insecurity problem, and what are the correlates of food insecurity?

However, these measurements still have limitations in view of the multidimensionality of food security. This is so in that matters like access to available food has gender and cultural relations that account for differentials in intra-house allocation, thus measurement of household level food availability does not ensure access by every individual member (Negin *et al.* 2009). As biological utilization of the food consumed also depends on non-food factors e.g. hygiene, access to potable water, health conditions and knowledge of an individual on basic principles of nutrition, measures of dietary intake may not always indicate the nutritional security of an individual (Negin *et al*. 2009; Barrett 2010). Therefore, a combination of different proxy measures is useful in supplementing the limitations of different indicators in estimating food security at household or individual levels.

3.9 Research gaps

In Zambia, there is considerable amount of research work related to climate issues, (for example, Jain 2007; Bwalya 2010; Kalinda 2011) to mention but a few. However, we cannot say there is ample scientific knowledge available on the impacts it has had and also to aid in proposing viable coping and adaptation strategies to climate variability and change and its impacts particularly on rural household food security. This study tries to fill in this knowledge gap and will help Zambia implement effective and acceptable climate change adaptation measures with respect to food security impacts of climate variability and change.

Further, empirical studies available on the subject provide climatic scenarios characterized by increase in temperature and reduction in rainfall (e.g., Belloumi 2014; Akadugu *et al* 2014; Mihran 2011). As a result of this climatic situation, crop production is said to have been affected negatively, thereby affecting food security negatively. Others like Obasi and Uwanekwu (2015) provide a climatic scenario where both temperature and rainfall have increased, thereby causing an increase in production. This scenario results in corresponding improvement in the food security situation. This study however, presents a unique climatic scenario, in that unlike other regions, southern Africa and Zambia in particular has no long term trend in rainfall. Instead, the rainfall situation is characterized by inter annual variations. This study therefore exploits this knowledge gap.

More specifically, most climate studies in Zambia have concentrated on the impact of climate change on crop and livestock productivity while other studies have assessed perceptions and adaptation (for instance, Kalinda *et al*, 2011; Jain 2007). Besides, these studies have concentrated on the national level and have not taken the climate issues to the lower or the micro level. No study thus far has been conducted at district level on climate variability, change and food security at household level with a focus on rural households. There is therefore a dearth of literature on the relationship between climate variability and change, and rural household food security in Zambia. The study addresses this gap.

3.10 The Theoretical and Conceptual Framework

3.10.1 The theoretical framework

Different theories have been used in social sciences to explain the issue of food security. However, to elucidate the link between climatic changes and food security, the study applied the Food Systems Approach. This approach is drawn from the systems approach which is based on the premise that food security is a complex issue linked in a complex system composed of rainfall, soil characteristics, agronomic practices, socio-cultural and economic characteristics of the farmer and institutional arrangements (Wambua, 2008). The approach therefore provides illumination regarding how agricultural production is determined by the interrelationship between different components such as biophysical, socio-economic and political attributes (Singh 1987; FAO 1990; Andrew 1997).

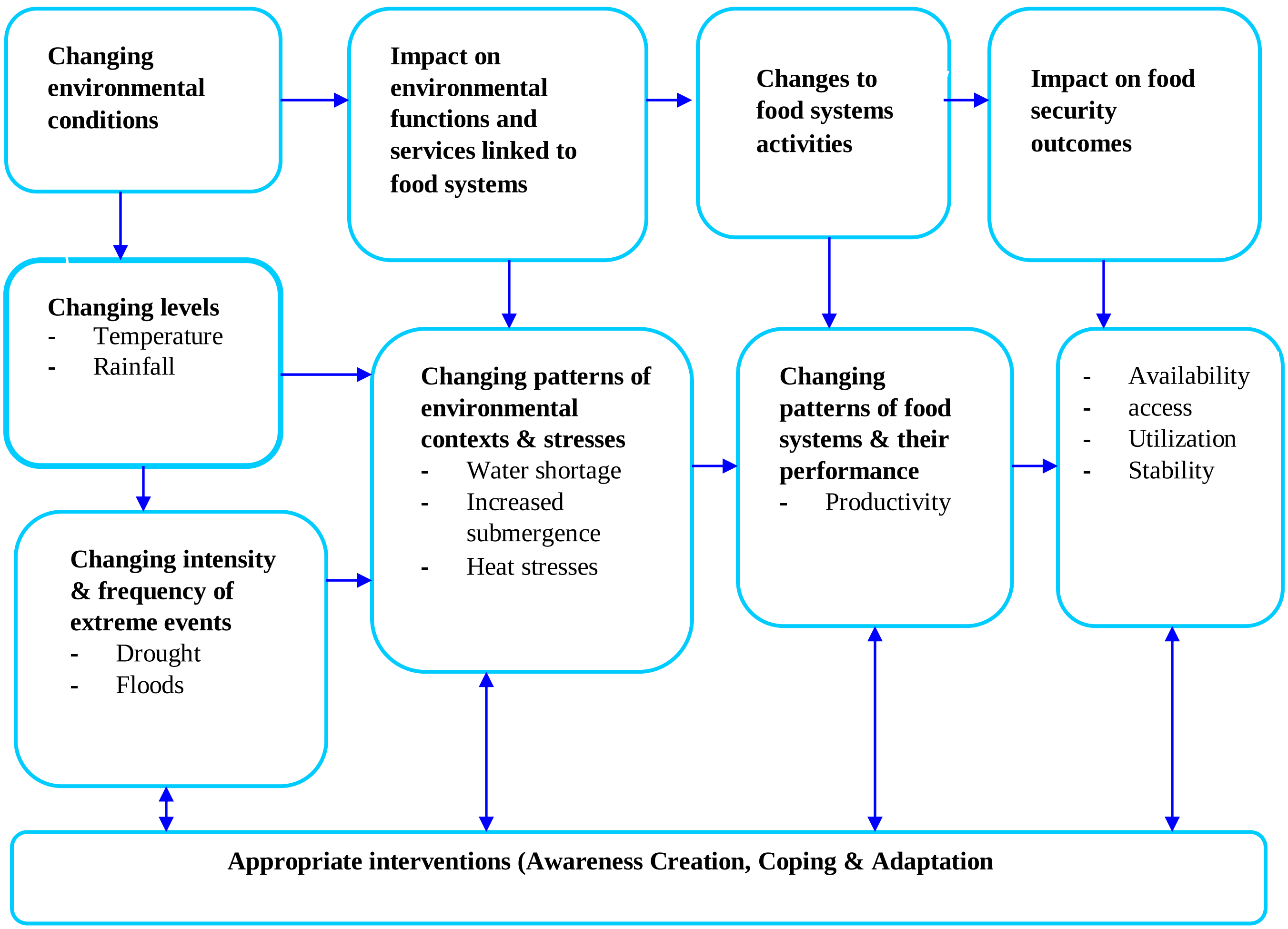
The food systems approach is based on food systems, which refer to a set of activities involved in producing, processing and packaging, distributing, retailing and consuming food (Ingram, 2015). Therefore, this approach comprehensively describes all of the activities, processes and outcomes involved in modern food systems and all possible interactions with global environmental change. In other words, the approach explains the interaction between and within the bio-geophysical and human environments which determine how food system activities are carried out.

The present study focused on the production component of the food systems with emphasis on how climatic changes and variations affect food production, thereby causing a corresponding effect on food security outcomes. The drivers comprise the interactions between and within bio-geophysical and human environments which determine how food system activities are carried out. According to Ingram, these activities lead to a number of outcomes, some contributing to food security and others contributing to environmental and social concerns. Some drivers also affect food system outcomes directly (e.g. household income levels). Finally, it should be mentioned though that food system activities and outcomes result in processes which feedback to environmental and socioeconomic drivers; food systems themselves are drivers of global change.

However, it is important to note that this approach is focused on global and national food security and does not take into account the aspect of food security at the household level. In view of this, the current study examined how the approach relates to household level food security in rural areas and the inter-linkages are demonstrated in figure 3.1., which provides the conceptual framework for the study.

3.10.2 The conceptual Framework

Figure 3.1: The conceptual framework



Source: Adapted from Ingram *et al*, 2010.

The study adapted the conceptual framework provided by Ingram *et al* (2010). The framework explains the environmental conditions and environment-related stresses that have relevance for food system functioning, food system measures of performance and food security outcomes. These factors are grouped and displayed in the four vertical columns of Figure 3.1. These are not meant to be completely exhaustive sets of all possible factors; rather these represent those that were considered in the study. The conceptual element of Figure 3.1 is an attempt to describe graphically the pathways of relationships (linkages) flowing from left - changing environmental conditions (independent variables) to right - food security outcomes (dependent variables) that received attention in the assessment (study). These linkages or relationships are represented by arrows connecting specific factors.

These linkages start with changing levels and patterns in environmental conditions (temperature and rainfall). Changes in these aspects are indicative of changing environmental conditions. These changes are associated with corresponding changes in the intensity and frequency of extreme events like drought and floods. These environmental changes affect environmental functions and services linked to food systems. These effects result from changes in patterns of environmental contexts such as change in water shortages, heat stresses and increased submergence. These changes affect the capacity to support food/agricultural production in an area. According to this framework, the metric of food/agricultural production impact is most commonly cited as change in crop yields. This change in crop production will affect the food security.

The framework further shows how appropriate interventions are key in moderating climatic impacts on food systems, and hence the food security situation. For example, awareness creation on why and how people, ecosystems or food systems are vulnerable to climatic shocks, stresses or long-term climate change is the key to developing coping and adaptation options to the food security effects of climate variability and change. This is because devising appropriate adaptation and coping measures is key in determining the final food security outcome.

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1 Introduction

This chapter highlights the research methodology that was used in conducting the study. It covers the research design, target population, sampling design, data collection methods and data analysis and techniques.

4.2 Study Design

According to Kothari (2011), a study design is a definite plan determined before any data are actually collected for obtaining a sample from a given population. The study used cross sectional research design. This design was adopted because it presented the basis for understanding the experiences of the rural households with regard to food security in the context of climate variability and change. Besides, the design also helped in understanding aspects of the study such as the awareness of climate change in rural households as well as the adaptation and coping strategies the rural households had employed. It was also favored because it presented the researcher with freedom and flexibility in terms of research methods in case there was need to change especially if some challenges related to data collection came up.

4.3 Study population

The population used in the study was that of rural households in Choma district. The district had about 23,356 rural households dotted in the 20 wards of the two constituencies (Choma central and Mbabala), (CSO, 2010). It should be noted however, that the last census in 2010 was conducted before some parts of the district had been annexed to be part of Pemba district, formed in 2013. Therefore the seven (7) wards that were part of Choma district during the 2010 census, and then moved to be part of Pemba district in 2013 were not included.

4.4 Sources of data

The study used both primary and secondary data.

4.4.1 Primary data

Primary data was collected through questionnaire interviews and semi structured interviews. The self-administered questionnaires were used on the head of each household that was sampled while semi structured interviews were conducted on key informants. Data collected from the households was on household food security situation, climate change and variability situation in the area, including awareness and adaptation. The key informants were asked questions related to the institutional perspectives of the problem of climate change, variability and food security in the district.

4.4.2 Secondary data

The study used secondary data on mean annual temperature and rainfall for Choma district from the Zambia Meteorological Department (ZMD). The data obtained was from 1976 – 2014. Further, crop focust survey (maize production) data for the district for the same period was obtained from the Central Statistics Office (CSO).

4.5 Sample size and sampling techniques.

4.5.1 Sample size

The study had a sample size of one hundred rural households. In addition to the rural households, the study picked on ten key informants. The one hundred households were determined using Nasuirma (2000) model of determining the sample size, while the 10 key informants were selected purposively. The Nasiurma model asserts that a sample size (n) can be determined by the equation:

$$n = \{NC_v^2\} / \{C_v^2 + (N-1)\, e^2\} \qquad (1)$$

Where: N = is the target population

Cv = is coefficient of variation

e = desired level of confidence

For this study:

N = 23,356 (this was the estimated number of rural households for the whole district)

Cv = 0.5

e = 0.05.

Therefore: $n = \{NC_v^2\}/ \{C_v^2+ (N\text{-}1)\ e^2\}$

$23{,}356\ (0.5^2)/\ 0.5^2+ (23{,}356\text{-}1)\ 0.05^2$

5839/58.3775

100.02

n = 100 households

In addition, ten (10) key informants were drawn from community leaders, the village headmen as well as officials from the Ministries responsible for Agriculture and Environment as well as those from the Meteorological Department.

4.5.2 Sampling procedure

The study used multi – stage sampling in the selection of the sample. This was done by first conducting cluster sampling which involved dividing the study area into geographical units (clusters) for purposes for easy coverage. In this case, the most convenient cluster was the Ward. A ward is an administrative unit headed by a Ward Councilor. Wards were used in the sense that household related data, such as population data, can easily to find from local authorities as well as the Central Statistics Office at the ward level.

Thereafter, simple random sampling was used in selecting the sample of five clusters (wards) from a total of twenty. The clusters were picked using simple random sampling where names of wards were written on small pieces of paper which were then folded and shuffled in small box. Thereafter, five of the folded pieces of paper where drawn from the box and these provided the randomly selected clusters. Five wards were picked on account of cost implications and available time.

Thereafter, from each ward two (2) villages were randomly selected and it was from these villages were the households interviewed were drawn. Villages were used in drawing the sampled households as they provided the sampling frame as opposed to the ward which only provided the household statistics. The sampling frame was provided by the village headmen as they were able to give the names of the households under their care. The number of households to interview in the two selected villages was on a proportional basis to the required sample size for each respective ward and the households were selected randomly (using simple random techniques). The distribution of the sample is shown in table 4.1.

Table 4.1: Sample distribution in each ward

WARD	NO. OF HOUSEHOLDS	SAMPLED HOUSEHOLDS
Batoka	1,260	19
Mang'unza	992	15
Siasikabole	1,414	21
Singani	1,585	24
Stateland	1,355	21
TOTAL	**6,606**	**SAMPLE TOTAL = 100**

Source: Researcher (2015)

4.6 Methods of data collection

Qualitative and quantitative data was gathered for this study.

4.6.1 Questionnaires

One of the main data collection methods that was used is self-administered structured questionnaires with closed and open ended questions. As people who were born, bred and live in the study area, it was expected that the individuals interviewed would bring on board their experiences as well as knowledge on climate variability and change together with its effect on household food security in the study area. Information collected was grouped into five (5) categories, these being: Basic characteristics of the respondents, information regarding climate variability and change, household food production and food security, climate change awareness, adaptation and coping measures to the food security effects of climate change and variability.

4.6.2 Interviews

Key informant interviews were conducted on a face to face basis which enabled the researcher seek new insights, ask relevant questions, and assess the phenomena of climate variability and change manifestations and their impacts on food security in rural households. Individuals deemed to be knowledgeable as well as community leaders constituted the key informants. The choice of key informant interviews over other qualitative data collection techniques was because of the fact that it provided the necessary platform for the researcher to elicit in-depth views from a wide range of people including professionals, community leaders and residents who had first-hand information or knowledge on the topic.

4.7 Methods of data analysis

Given the complexity and uncertainty of issues involved in climate analysis, the analysis did not only involve statistical analysis, but also social and institutional perspectives to uncover the depth of the impacts that climate variability and change on rural household food security, climate change awareness and the coping and adaptation strategies. In view of this, both quantitative and qualitative techniques were used to analyze the collected data.

4.7.1 Quantitative data analysis

Quantitative data on mean annual temperature and rainfall as well as district level production of the staple crop (maize) from 1976 to 2014 was used in quantitative analyses. The climatic data was used to show the trends in rainfall and temperature in the district during this period. It was also entered in the regression analysis, which was the main statistical method of analysis. Data on district level production was used to check trends in production of the staple crop (maize) and was also used in the regression analysis to determine the relationship between climate factors and food security. To show the trends, line graphs were produced from these data using Microsoft excel in order to necessitate trend analysis.

In order to deal with household food security and climate which is an interdisciplinary subject, Correlation and Regression Analysis were used to specifically establish whether there was a relationship between the independent variables (climatic factors) and the dependent variable (food security) and well as to determine the effect of the climatic variables on food security.

According to Blalock (1979), correlation and regression analyses could be extended to include any number of interval scales, one of which could be taken as dependent variable and the other independent. Multiple Regression Analysis was used in this study as it is shown by previous researchers to be a useful technique of measuring multivariate statistical relationships. As was the case in this study, more than one independent variable was used against a single dependent variable. It should be mentioned that various models on the analysis of household food security encompass some forms of regression. An example of such is the econometric model used in many studies including, Demeke *et al* (2011). For this study, the regression factors used were mean annual temperature and rainfall from 1976 to 2014, in degrees Celsius and millimeters respectively and hypothesis testing was done at 0.05 significance level. The study used SPSS tool to conduct this analysis.

In terms of the food security, it should be mentioned that there is no single tool to measure the complex nature of this variable. Instead, different indicators are used as a proxy for household food security. This study used one quantitative indicator; district level production of the staple crop as the dependent variable in the regression analysis. This indicator was chosen as it provided an appropriate match to the climatic data used in the study. The other reasons were particularly academic. For instance, according to Maxwell and Frankenberger (1992), one critical dimension of household food security is the availability of food in the area for the households to obtain. Regional food shortages have a strong influence on household food availability and options households have for access. Furthermore, Barton and Shohan (1991) described this indicator as a risk of an event indicator in that it provides information on the likelihood of a shock or disaster event that will adversely affect household food security. This indicator has been used by Wineman (2014), as a measure of household food security in a study conducted in Zambia and included Choma district. The regression model that was employed is as follows:

$$Y = \beta_0 + b_1 X_1 + b_2 X_2 \ldots\ldots\ldots\ldots b_n X_n + e \qquad (2)$$

Where;

Y = household food security

β_0 = constant or intercept

b = regression coefficient

x_1 = temperature

x_2 = rainfall

e = error term

In addition, partial regression plots were done to establish relations between each independent variable and the dependent variable. Also, descriptive statistics were used to analyze quantitative data and results were presented either as percentages or counts. The use of descriptive statistics was appropriate because the descriptive analysis helped in transformation of data in a way that described the basic characteristics like central tendency, distribution and variability. The descriptive statistics, tables, and other graphical presentation were used to present the data collected for further understanding and analysis.

4.7.2 Qualitative data analysis

A robust qualitative analysis approach was employed to compliment and enrich the statistical data collected from the respondents in the study area. This involved a comprehensive reveal of responses both from the household heads and the key informants on food security situation, climate change awareness together with the adaptation and coping strategies employed. From these responses, main themes were identified, classified and then assigned codes. This necessitated the effective capture of opinions and experiences into the main text.

Qualitative data was collected to solicit experiences and views from the sampled households mainly on four aspects of the study. These were; their household food security situation, perceptions on climate variability and change, climate change awareness as well as the adaptation strategies and coping strategies adopted by the households to mitigate the food security effects of climate variation and change.

With respect to the household food security, two qualitative indicators were used. These were; the period of household food shortage and the households' perception of their food security situation. Aluoko-Odingo (2006) and Bekele (2013) are some of the researchers that have used these indicators in their studies, with Aluoko-Odingo having used period of food shortage in

Nyando district, Kenya, while Bekele employed household perceptions as an indicator for household food security in Ethiopia. With period of household food shortage, this investigation focused on the months when the households depended on the staple crop produced from their own farms as well as months dependent on crop/food purchases, relief food and other sources. Households that reported having no incidences of food shortage were considered food secure and the households that reported experiencing food shortages and therefore had months where they depended on relief, food purchasing etc., were considered food insecure.

With respect to households' perception of their food security, food security was measured on the basis of the perception of the respondents regarding their household crop production and market prices for the staple. Maxwell and Frankenberger (1992) argue that people‘s own perception of food security is an important measure of household food security. Whether the households had recorded increases in production quantities of the staple crop or not over the past years up to the present and whether or not the price of the staple (maize grain and maize meal) was okay especially during periods when the stock grown runs out were used as a basis for conclusion. This analysis also included understanding whether or not households worry about food shortage and also whether the amount of food consumed is below their desired quantity. The indicators used for this analysis were drawn from the household food insecurity access scale (HFIAS) which has been widely applied to measure different aspects of food security (Becquey *et al.* 2010; Thorne-Lyman *et al*. 2010; Regassa and Stoecker 2012). For this study, the indicators are similar to the ones used by Bekele (2011) in a modified household food insecurity access scale.

In sum, the food security indicators employed in this study have strong conceptual validity. They cover important aspects of the definition of household food security - access, sufficiency, stability and quality - and capture these aspects very well.

4.8 Limitations of the study

The research was limited in some aspects for particular reasons. The questionnaires and interview schedules that were used for data collection were prepared in English which could not be used as a media of communication with the rural household respondents. Therefore interpretation had to be used to translate the questions into local languages in order for respondents to answer the questions.

4.9 Ethical considerations

Considering that the study was conducted in a rural setting, clearance had to be obtained from the local leadership, in this case the village headmen. The study also observed informed consent where, assurances of confidentiality and anonymity were given to all participants. Respondents were thoroughly briefed on the purpose of the study, the intended use of the data obtained from them as well as the potential result of the study.

CHAPTER FIVE
RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter presents the research results, data analysis and discussions in line with the study objectives. It starts with the demographic characteristics of the sample and then the data and results for objective (1) up to (4).

5.1.1 Demographic characteristics of the sample

The sample was drawn from five wards and ten villages and one hundred respondents where targeted to take part in the study. However, out of these, 87 (87 percent), took part and the other 13 (13 percent) could not take part in the study for various reasons. They could not be interviewed as they were not available at their homes for various reasons, (sickness, visiting relatives, etc.) during the data collection period.

5.1.2 Distribution according to gender

Of those interviewed, 83 were male headed households and 4 were female headed. This means there were 95 percent male headed households and only 5 percent female headed households. Therefore, the number of male headed households was much more than female headed households in the study area. The implication of this finding is that the representation of male headed households is stronger. It is important to note that because household responsibilities are gender specific especially in the rural set up, women headed households may not be as productive as men headed households. In the villages for instance, some food production activities such as ploughing heavily rely on access to male labor, without which women headed households may face delays that may lead to losses in food production. However, the influence of this factor on the results was minimal due to fewer female headed households. On the other hand, Mandleni (2011), points out that gender has no significant effect on climate change awareness, but on adaptation to climate change.

5.1.3 Distribution of households according to occupation

Some household heads were found to engage in more than one occupation and therefore responses were not mutually exclusive due to the multiple responses

Table 5.1: Occupation of household heads

Occupation	Frequency	Percentage
Farming	87	100
Work employment	12	14
Others	23	26
TOTAL	**122**	**140**

Source: Field data (2015)

What is worth noting however, from this table is that all the household heads interviewed were engaged in farming. This confirms that agriculture as the main livelihood activity of the rural people in Choma district and this tally with Jain (2007), CSO (1992) and MoA (2000) who wrote that rural households in Zambia are occupied with crop production for subsistence and as a source of income.

5.1.4 Crops grown by the households

The households were asked to name the crops that they grow. The responses from the households as shown in table 5.2, were not mutually exclusive as most of the households were found to be engaged in mixed farming.

Table 5.2: Crops grown by the households

Crop	Frequency	Percentage
Maize	87	100
Sweet Potatoes	69	79
Groundnuts	44	51
Sunflower	02	2

Source: Field data (2015)

As expected of the district and the province at large, table 5.2 shows that maize was the most commonly cultivated crop among the rural households in the district. All the respondents cultivated at least one variety of maize, confirming the fact that is the staple crop of the district. Other crops that were said to be grown are sweet potatoes, groundnuts with a few households mentioning sunflower. According to the respondents, these are optional crops grown mainly as support to the main crop (maize). For example, groundnuts are mainly grown by women on small plots or fields as groundnut powder is used as a cooking additive, while sweet potatoes were said to be an important breakfast meal particularly during their harvest season (cold season) while some are sold.

5.2 Climatic trends in Choma district

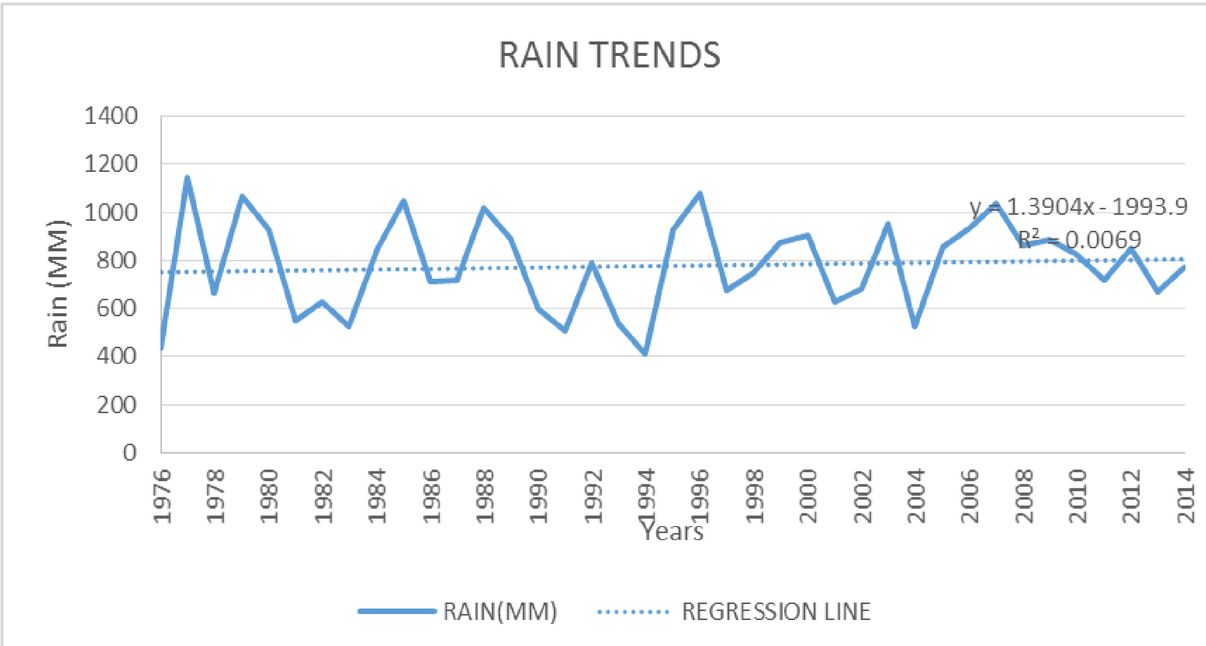
The climatic trends for Choma district were based on two climatic variables; mean annual rainfall and temperature and data on those two variables was panel, from 1976 to 2014. This data is presented in appendix 2.

5.2.1 Rainfall trends in Choma district from 1976-2014

In order to determine the trends in rainfall over this period, mean annual rainfall data for the period was graphed as shown in figure 5.2. The means for the rainfall represent the average rainfall received in the district for each of the years from 1976 to 2014. This data was obtained from the Zambia Meteorological Department and is shown in appendix 2.

The plot as indicated by figure 5.1 shows that the district had been experiencing fluctuations in rainfall activity from 1976 to 2014 as evidenced by fluctuations in the solid line. The curve shows that the district received a minimum of 400mm of rain and a maximum of close to 1200mm during the period. Generally, it can be said that the district had experienced both high and low rainfall activity over the period. However in terms of the period trend, represented by the linear regression line, the line shows a marginal rise in rainfall from 1976 to about 2004. This could be attributed to above normal rains received in the district, for example in 1977, 1986 and 1997, to just mention a few. From 2004, the trend line is perfectly flat while the solid line shows decrease in the rainfall pattern between 2007 and 2014. However, largely, the regression line is almost horizontally flat for the whole period indicating that the district did not have much change in rainfall activity during the period.

Figure 5.1: Graph showing rainfall trends in Choma district



Source: Researcher (2015)

Source: Field data analysis

Views were also sought from the households regarding rainfall patterns in their areas. The respondents were asked to state what they had observed about rainfall from five perspectives, namely; length of the rainy season, frequency of precipitation, frequency of dry spells, length of dry spells as well as occurrence of floods. The perceptions from the responses were based on whether or not these aspects had increased, decreased or there was no change (rainfall had remained the same).

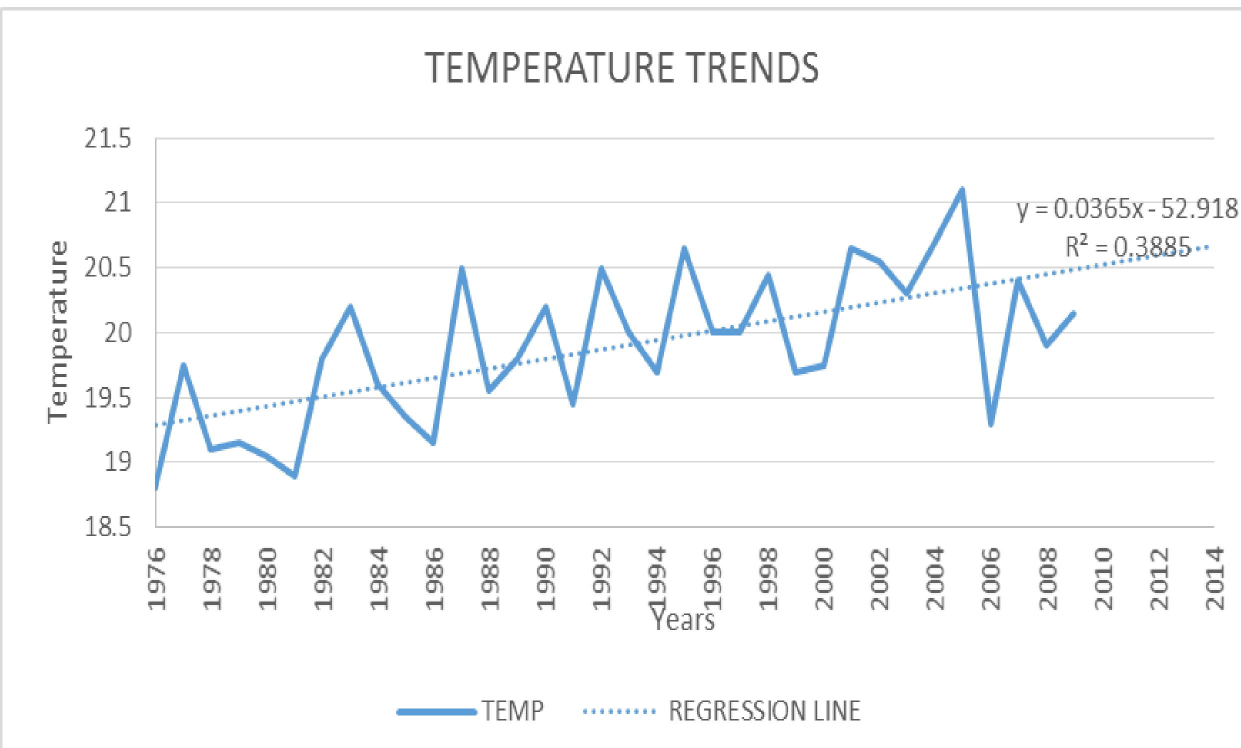
Based on the responses, all the respondents reported that there was a decrease in length of the rainy season as well as the frequency of precipitation. With regard to dry spells, all the respondents reported that the frequency and length of these had increased. On floods, the respondents reported that the area had not experienced floods as far as they could remember.

One of the typical examples of these scenarios according to the respondents was the 2014/2015 season when the start of rains delayed only to commence in mid-December and then long dry spells in the area followed in the months of February and March. Records from the provincial agricultural office, MOAL (2015) showed that between October and December of 2014, the district had 6 rainy days translating to 89mm of rain. This was low compared to other districts in the province like Livingstone which had 25 rainy days and 251mm of rain.

5.2.2 Temperature trends in Choma district from 1976 to 2014.

To determine the trends in temperature over the period 1976 to 2014, the mean annual temperature data for the district, were presented in a graph as shown in figure 5.3. The mean annual temperatures were calculated from the average monthly temperatures and therefore represented the average temperature for each of the years under review.

Figure 5.2: Graph showing temperature trends



Source: Field data analysis

The plot shows that the district had both rise and falls in annual temperature. The graph shows that the district had experienced mean annual temperatures ranging between 19^0 Celsius and 21^0 Celsius. Also, the district had in some instances experienced inter annual temperature variations while other years exhibited consecutive uniform mean annual temperatures, the longest of these between 1994 and 1998. However, in terms of the overall period trend (represented by the linear regression line), it shows that the curve is rising for the whole period. This rise in the regression line indicates that the temperature had been increasing in the district during the period under review. The upward trend exhibited in the graph therefore shows that mean annual temperatures in the district have increased since 1976.

Views were also sought from the sampled households on the observations they had made regarding the temperature trends in their areas. The respondents provided mixed reactions with regard to temperature situation with 56 percent reporting that the temperatures in the area had increased, while 17 percent reported that it had decreased and the 27 percent reported that they had not noted any temperature changes.

5.2.3 Discussion on rainfall and temperature trends

The results and responses on the rainfall variable show that Choma district had experienced rainfall patterns characterized by both decrease in rainfall activity (below average rains) as well as increases (above normal rains). The general rainfall trend for the district shows that there had not been a significant change in rainfall pattern over the period. This rainfall pattern characterized by inter annual variations has been associated with dry and wet spells and this corresponds with Kanyanga (2008), who reported that the country has experienced an increase in drought spells as evidenced by the droughts of the years 1987, 1992, 1994,1995,1996,1997, 1998, and 1999. He further adds that after 2000, there has been a slight increase in rainfall activity which could be attributed to the above normal rains received in the 2005/06 and 2007/8 season. Therefore, Kanyanga's findings show fluctuations in rainfall activity for the whole country, which corresponds to the case of Choma district. The scenario also confirms literature from Sichingabula (1998), that the climate in Zambia had been characterized by epic dry and wet episodes.

Furthermore, these findings are also consistent with IPCC (2007) which reports that inter annual rainfall variability is large over most of Africa while Nicholson *et al* (2000) reported that increased inter annual rainfall variability has been observed in the post 1970 period in Africa, with higher rainfall anomalies and more intense and widespread droughts. In addition, the findings are consistent with the regional trend in that as reported by Nicholsson *et al* (2000), no long term rainfall trend has been observed in Southern Africa. However, these findings are in contrast with other regions such as West Africa and the tropical rain forest that have exhibited a reduction in rainfall trend while some areas such as the Guinean coast have experienced an increase.

With regard to temperature, the mean annual temperature trend exhibited an upward rise, indicating increase during the period. This increase in mean temperature for the district corresponds with Jain (2007), who found that the country as a whole is experiencing increasing mean temperatures. Besides this, studies have revealed that over the past three decades temperature in the country has been increasing at 0.6 ^{0}C per decade (MTENR, 2007) and the increase in has been attributed to global warming.

More importantly however, it has been argued by Bwalya (2010) that these rainfall and temperature patterns are indicative of the effects of climate variability and change. The point is that these climatic trends which the district and the country at large is experiencing represent significant departures from average state of climate system. These patterns are attributed to climate variability, but are also signal that the country is going through long term climatic changes in mean temperature and rainfall norms, (MTENR, 2007). In addition, these trends confirm literature that Zambia's climatic conditions have changed in that since early 1980s, the rainy season has been starting late and the rains have been withdrawing early, and that temperature has been observed to have increased by one degree since the 1970s (GRZ, 2002). The World Bank (2006) also reported that Zambia has been experiencing an increase in floods, temperature and drought frequency and intensity, which many scientists have attributed to long term climate change.

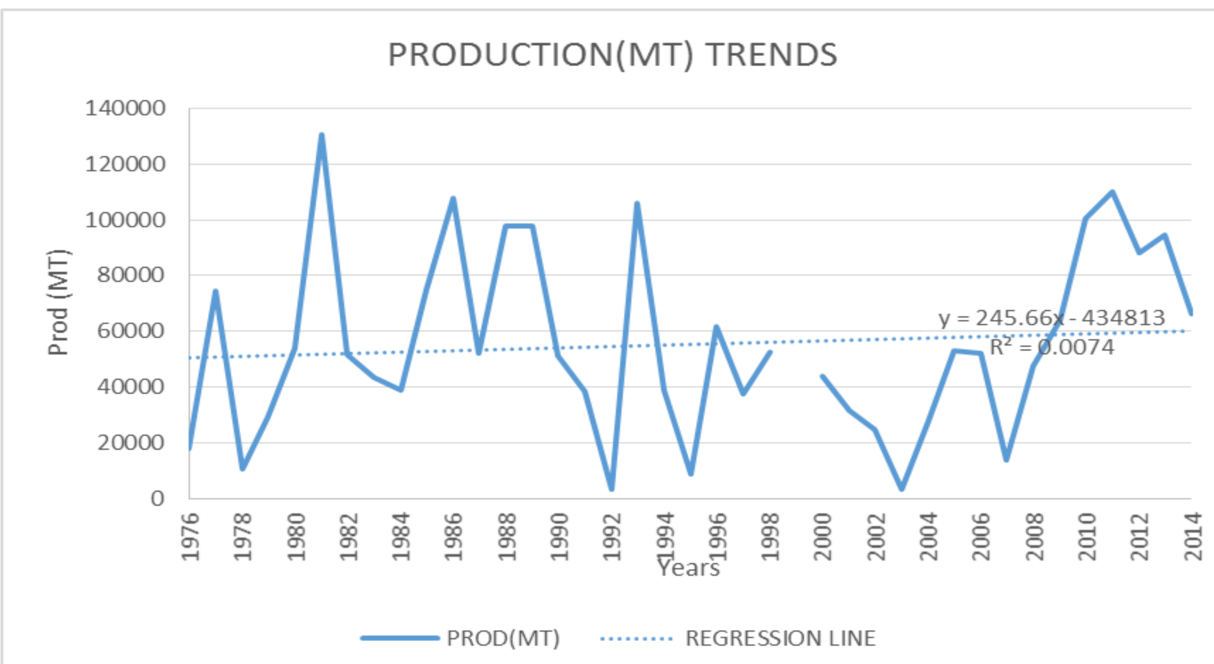
5.3 Rural household food security situation in Choma district

To establish the food security situation in the district, three indicators of household food security were used, namely; Crop (maize) production trend, Household period of food shortage and Households' perception of their food security.

5.3.1 District maize production from 1976 to 2014

Data on annual production of the staple (Maize) in the district from 1976 to 2014 was used shown in appendix 2. The production data used was based on annual Crop Focust Surveys. This data was plotted on a line graph to show the production trend in the district for the period as shown in figure 5.3.

Figure 5.3: Graph showing maize production trend



Source: Researcher (2015)

Key: Gap shows missing data

Source: Field data analysis

The picture of the trend is critical because of the close relationship between maize production and food security in the area especially that food security is based on maize production. Increased maize production results in corresponding rise in the food security situation at the rural household level, and the reverse is also true, in that reduction in production increases food insecurity at the rural household level. According to the Ministry of Agriculture, 97 percent of maize production in the district is directly attributed to the small and medium scale farmers who in this case constitute the very rural households which the study targeted. Therefore, the production trend was key for the study as it indicated whether the situation was pointing towards rural household food security or food insecurity.

Figure plot shown in figure 5.3 indicates that the production of the staple crop (maize) in the district had been characterized by considerable annual fluctuations since 1976 as shown by the solid line. It is evident from the graph that the district had experienced highs and lows in the production of the staple crop, a situation that can better be described as characterized by inter-annual variations. Because of the close link between production and food security, these fluctuations in production therefore contributed to unstable levels of food security in the households in that just as production fluctuated, the food security situation also did the same. However, the period trend (represented by linear regression line) shows a marginal rise in production from the 1976 to about 2004. This could be attributed to bumper harvests the district had in the 1981/82, 1991/92 just to mention a few, a situation that could have had marginal positive effects on the food security situation. Thereafter, the linear regression line is almost horizontal (flat) and the production curve (solid line) shows production going down. Generally, what is very evident is that the trend line is almost flat throughout the whole period indicating that there had not been a major change in production of the staple crop (maize) and hence the rural household food security situation during the period. Instead, production had been characterized by inter annual fluctuations, thereby making the rural household food security situation fluid. The implication of this is that the food security situation was bad in seasons when production is low and it improved when production was high.

5.3.2 Period of household food shortage

This was the second indicator of rural household food security situation in the district used in the study. This indicator of household food security centered on the period when the households depended on the crop grown from their farms to when this crop runs out, thereby creating food shortage resulting in a situation where the rural households have to depend on buying food as well as other alternatives. The months in focus were those in between harvesting periods, that is, April of one season to April of another. With this indicator, food insecurity was linked to household food shortage and therefore households that reported experiencing periods of shortage were considered food insecure, while those without shortage were considered to be secure. Responses from the households on the period of food shortage are shown in table 5.4.

Table 5.3: Period of household food shortage

Period (months)	Frequency	Percentage
1 – 3	7	8
4 – 6	38	44
7 – 9	23	26
No shortage	19	22
TOTAL	**87**	**100**

Source: Field data (2015)

From the responses in table 5.4, 22 percent of the households reported not having any food shortages and the rest, 78 percent reported having periods of food shortage. Therefore, from these results, 78 percent of the respondents were food insecure while 22 percent were food secure using this indicator. The 78 percent constituted households which relied on cultivation only for their food security, while the 22 percent secure households were largely made up of households that were in some forms of work employment, and therefore did not rely on production only for their household food security as their monthly incomes necessitated purchase.

The period of shortage according to the households largely depended on the level of yields and was not static *per se* as years of good harvest meant a shorter period or no shortage at all, while poor harvest provided the opposite. The level of yield according to the households depended largely on two factors; namely rainfall and availability of artificial fertilizer. Responses to the effect of these two factors were mutually exclusive. All the respondents pointed that rainfall determined the yields, while 72 percent attributed access to fertilizer as also a determinant. On the other hand, the situation also remained secure after harvests in April to August and this could be in addition to the fact that this period corresponded with sweet potato harvesting, thereby providing enough food which improves the situation. The longest period of food shortage was between 7 to 9 months and this was reported by 26 percent of the households. A larger 44 percent of the households reported having household food shortages for between four (4) to six (6) months. Only 8 percent of the households reported a shorter period of shortage of between one (1) to three (3) months.

These responses were however based on previous seasons as the respondents reported that the current season of 2014/2015 was going to present a completely different picture as the yields were projected to be very low with some reporting that they risked not getting anything at all from their fields. Therefore, this picture was expected to change completely and increase the period of household food shortage together with the number of households facing shortage. This means more households are going to be food insecure due to poor yields in the 2014/2015 season.

5.3.3 Households' perceptions of their food security.

This was the third measure of household food security in the area used by the study. Using this measure, the household food security status was determined on the basis of how the households perceived their situation based on whether they were worried or not with their food security situation on account of whether the following parameters had increased, decreased or there was no change at (meaning the variable had remained the same according to the respondent); maize production, food shortage months, amount of food in the home, amount of food consumed in the home, number of meals as well as the price of the staple food (Maize grains and Maize meal). These indicators were picked from the household food insecurity access scale (HFIAS) which is widely applied to measure different aspects of food security. For example, the internationally recognized number of meals an adult should have in a day is three, and it is on such bases that these indicators were anchored. However, other aspects such as price, yield, amount of food consumed were generally based on the households' requirements and capacity. Responses from the households on these indicators are shown in table 5.5.

Table 5.4: Household food security perceptions

PERCEPTION FREQUENCIES			
INDICATOR	**Increased**	**Decreased**	**No change**
Maize yields	0	79 (91)	8(9)
Food shortage months	67(77)	0	20(23)
Amount of food	0	67(77)	20(23)
Food consumed	0	87(100)	0
Number of meals	0	6(7)	81(93)
Price of staple	87 (100)	0	0

Key: Figures in parenthesis are frequency percentages

Source: Field data (2015)

With regard to maize production, 91 percent of the respondents said production had decreased while 9 percent reported not having observed any changes. None of the households interviewed reported an increase in production of maize. On the aspect of food shortage months, 77 percent of the respondents reported that the period of food shortage in their households had increased and 23 percent reported having had no changes. None of the households interviewed reported increase in production of maize. On the aspect of amount of food in the homes, 77 percent of the households reported not having enough (decreased) and the other 23 percent reported being okay, as their situation had not changed. No increase was reported from the households. With regard to the amount of food consumed in the households, all the households reported that the amounts had decreased. What is worth noting with this aspect is that even the households that reported being okay, reported reduction in consumption, possibly as a food saving measure. On the number of meals, only 7 percent of the households reported not having three meals at times while 93 percent reported having no change in the number of meals. Finally, with respect to the price of the staple, all the respondents reported that the price for both Maize grains and Maize meal had increased.

Based on these indicators, all the respondents reported being worried about their household food security situation. In particular, all the households interviewed reiterated that they were food insecure as the prevailing environment did not support a secure status. It was evident that the respondents were increasingly getting concerned and worried of the changing patterns in the household food situation.

5.3.4 Discussion on the rural household food security situation in the district

These findings on the household food security situation provide proof that there is food insecurity in the rural households of the district. It was clear that production of the staple was going down putting the rural households at risk of food insecurity. This food security situation confirms literature on the fact that food insecurity is traditionally associated with rural areas, (Mulenga, 2013). This food insecurity in the rural households is linked to the fall in production of the staple. This also confirms literature that Zambia's food security situation is serious despite the occasional surpluses the country produces during good crop years. As rightly argued by Kalinda *et al* (2008), whichever measure of food security one uses, Zambia is no longer able to feed itself and this was found to be the case for Choma district.

What is clear from the findings is that the households have adequate food for consumption for the April to August/September, mainly from own production. Food insecurity during this period remains at Minimal levels as the households have adequate staple food supplies and as farming households access own-produced staple foods and other seasonal foods from the current harvest. However, minimal food consumption starts from July to September as most households have reduced food stocks. After September and October, households have to engage in normal coping strategies. This is compounded by higher maize grain and maize meal prices that are typical for this period as supplies are low and most households are market-dependent while own production is depleted and households do not yet have access to the new harvest.

However, it is important to note that the food security situation in the district was not static, instead it was largely characterized by fluidity. Because the rural households largely depend on own production for their food security, what was established is that the situation tends to improve when yield from household production is good and the situation is opposite when production is bad. As a result of this, the situation continuously changes such that a household that is food secure this year, may be secure the other year and vice versa.

5.4 Effect of the climatic situation on rural household food security in Choma district

To establish whether the climatic situation in the district had an effect on rural household food security, Multiple Regression Analysis and Pearson's correlation were conducted. Pearson's correlation was conducted to determine whether there was a relationship between the climatic factors and the rural household food security situation. Multiple regression analysis on the other hand was conducted to establish the effect of the climatic situation on food production, and hence the food security situation as well as to ascertain whether the effect (relationship) was significant. Mean annual temperature (X_1) and rainfall (X_2) from 1976 to 2014 were independent variables, while district level annual production (X_2) for the staple crop (maize) for the same period was used as the dependent variable in these analyses (data presented in appendix 2). The results of the regression are shown in table 5.5 and 5.6.

Table 5.5: Multiple Correlations Coefficients of climatic factors and production

		Production	Rainfall	temperature
Pearson Correlation	Production	1.000	.032	-.343
	Rainfall	.032	1.000	.015
	temperature	-.343	.015	1.000

Source: Correlation and regression analysis

Table 5.6: Mutiple Regression coefficients of climatic factors and food production

Coefficients[a] **R^2 = 0.119**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	407304.479	181731.067		2.241	.033
RAIN(mm)	5.744	26.206	.038	.219	.828
TEMP(^{0}C)	-18201.393	9089.332	-.343	-2.003	.054

Source: Correlation and regression analysis

5.4.1: Effect of climatic situation on production and household food security

The results of showed that there is a relationship between the dependent variable, rural household food production (Y) and the independent variables (temperature X_1 and rainfall X_2), since no correlation coefficient is zero. The results are given in table 5.5. However, the correlation coefficients for between the climatic variables (rain and temperature) show that both had a week relationship with production. The Pearson's correlation coefficient was highest between temperature and production with a negative correlation and lowest between rainfall and production, with a positive correlation. In general, these relationships show that the climatic situation in the district is related to the food production of the staple crop, and hence the rural household food security situation.

On the other hand, table 5.6 shows that the coefficient of determination, R – squared, is 11.9. This means that the climatic factors used in the analysis (mean annual rainfall and mean annual temperature) accounted for 11.9 or 12 percent variation in the production of the staple crop (maize), and hence the household food security situation in the district. The remaining 88 percent could be attributed to other factors that affect maize production. This shows that the two climatic variables were important determinants of the rural household food security situation. The resulting equation from the regression is:

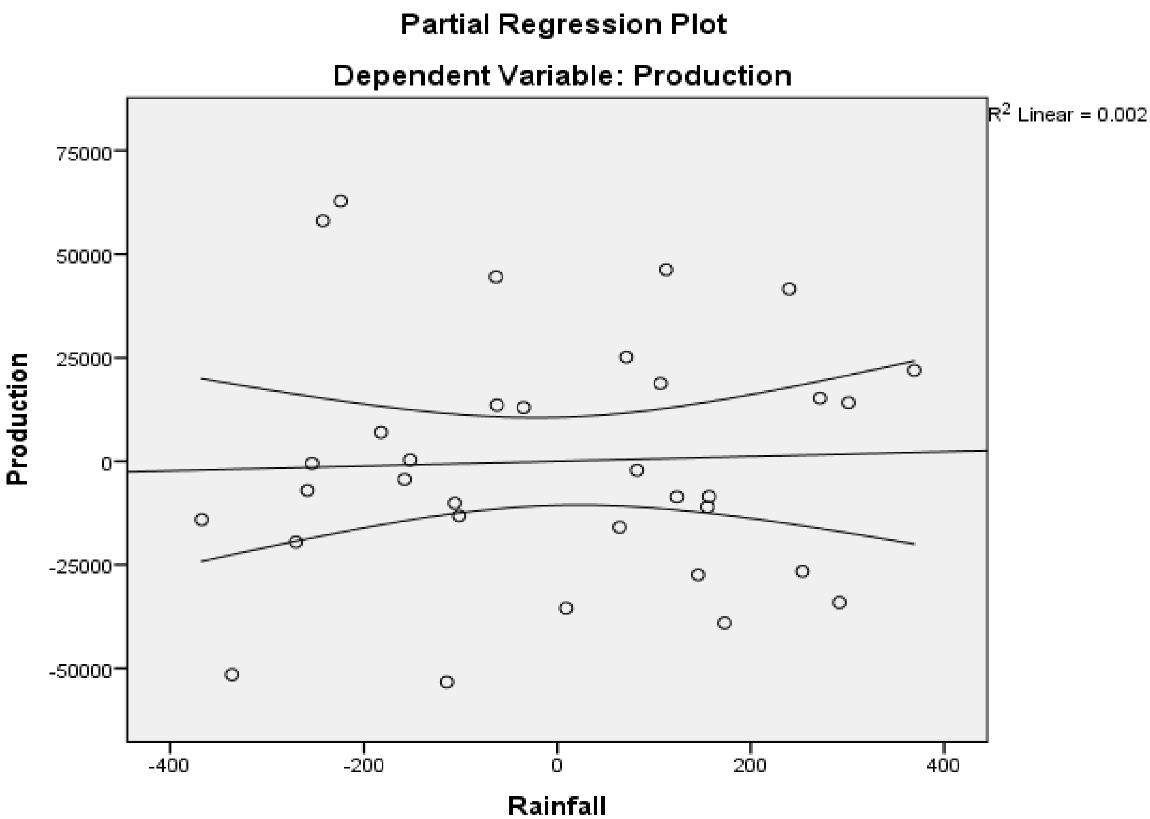
Y = 407304.479 + 5.744 rainfall -18201.393Temp

The equation indicates that there was a positive relationship between mean annual rainfall and maize production meaning that meaning that rainfall contributed positively to the rural household food security situation. In addition, the equation also shows there was a negative relationship mean annual temperature and maize production, hence indicating that mean annual temperature contributed negatively to the food security situation

The interpretation of the equation is that an increase of 1mm of rain results in 5.7 metric tons increase on production while an increase of 1^0C in temperature results in reduction of 18,201 tons in production. The reverse is also true that a decrease in rainfall would bring a corresponding decrease in output and a decrease in temperature would bring a corresponding increase in maize output.

To confirm these relationships together with the extent of the effect of each of the two climatic factors used in the regression analysis, Partial Regression Plots between mean annual rainfall and production as well as mean annual temperature and production were done as shown in figures 5.4 and 5.5. Figure 5.4 shows a partial plot between mean annual rainfall and production while 5.5 shows a partial plot between mean annual temperature and production.

Figure 5.4: Partial regression plot between rainfall and production



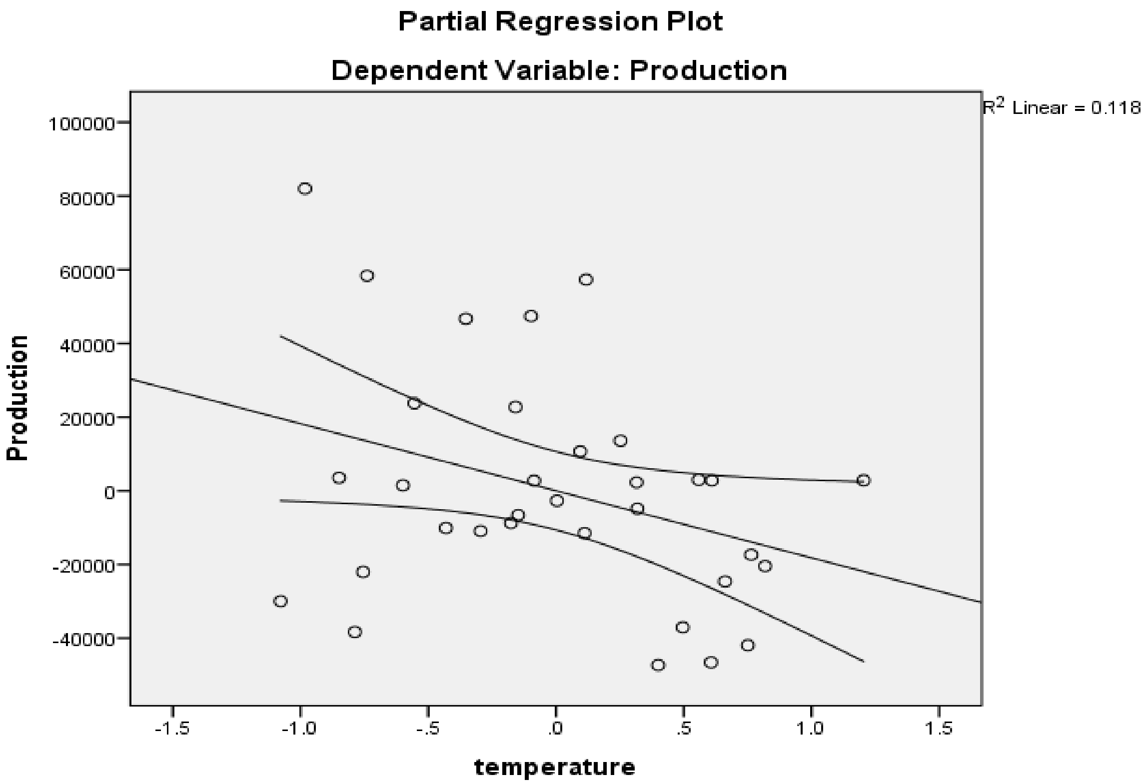
Source: Partial correlation analysis

Figure 5.4 provides a very good picture of the relationship between the two variables (rainfall and production) during the period under review. An important aspect to note from the graph is that it has two halves, below and above zero, with each half indicating the side of the relationship between the variables (depending on where the relationship curve passes). The bottom half represents a negative relationship while the top half, a positive relationship. The negative sign on the values denotes a negative relationship while the positive sign denotes a positive relationship. Therefore the relationship between the variables is either positive or negative when using this analysis. The resulting equation from this analysis is:

Y = 28292.34 + 3974.151rainfall

The equation shows that an increase of 1 millimeter of rain results in 3,974 tons increase in production. The equation also shows that rainfall and temperature have a positive relationship. A close look at the relationship curve shows that it falls slightly below zero (the negative side of relationship) and then crosses slightly above zero (on the positive side of the relationship). The curve shows a marginal rise from slightly below zero to almost the zero mark. There isn't much shift. This corresponds with the R^2, ($R^2 = 0.002$) which is extremely low (almost 0 percent), but it is a positive value. The interpretation here is that rainfall had a positive effect on production and a rise in rainfall caused a marginal rise in production during the period under review. The conclusion from this partial plot is that of the total contribution of climatic factors to production (and hence food security), the contribution of rainfall was positive through an extremely minimal rise, which was so negligible. However, the contribution of rainfall was very low (negligible) meaning that it was not a major determinant of production and hence the rural household food security situation. Instead there were other factors not included in this study that played a major role in the rural household food security situation.

Figure 5.5: Partial regression plot between temperature and production



Source: Partial correlation analysis

The interpretation of figure 5.5 is similar to the one on figure 5.4. The bottom half of the graph represents a negative relationship while the top half, a positive relationship. The negative sign on the values denotes a negative relationship while the positive sign denotes a positive relationship. Therefore the relationship between the variables is either its positive or its negative when using this analysis. The regression equation resulting from this analysis is:

Y = 1123047.701 – 358986.824temp

The equation shows that the relationship between production and temperature is negative. An increase of 1^0C would result a reduction of 358986.82 tons reduction in production. A close look at Figure 5.6 shows the curve moving from the positive half to the negative half of the graph. As temperature values increase, production went down (from positive to negative half). This indicates a negative relationship between the two variables. Therefore the increase in temperature during the period led to decrease in maize production in the district and hence the rural household food security situation. On the other hand, of the total contribution of climatic factors to production, the R^2 shows that temperature contributed about 11.8 percent to production. Therefore, the interpretation is that annual temperature contributed 11.8 percent loss in production during the period under review. However, this was a weak contribution such that it was concluded that temperature was not the main determinant of the rural household food production, and hence food security. Instead, other factors not included in the study played a major role in the rural household food security situation.

5.4.2: Hypothesis testing on whether there is a significant relationship between climate the climatic situation and rural household food security

To test this hypothesis, multiple regression analysis was used. In the analysis, temperature (X_1) and rainfall (X_2) were the independent variables while, district level maize production (Y) was the dependent variable. The results of the multiple regression analysis shown in table 5.7 indicate that the regression coefficients for rainfall (0.828) and temperature (0.054) are both greater than 0.05, which was the desired significance level.

This meant that the research hypothesis of no significant relationship between household crop production and climatic factors (temperature and rainfall) could not be rejected as there was no sufficient evidence to do so. It was therefore concluded that mean annual rainfall and temperature are not important determinants maize crop production and hence the rural household food security situation in the district.

5.4.3 Discussion on the effects of climate variability and change on rural household food security in Choma district.

Based on the results and analyses on sections 5.4.1 and 5.4.2, the climatic situation provided by the trends in rainfall and temperature is related to production of the maize crop in Choma district, hence affecting the food security situation. This supports literature from Jain (2007) who found that maize production had been quite variable in Zambia and that the major factors contributing to this low yield have been the long dry spells within a season and the shorter rainfall seasons which the country had been experiencing the previous 20 years. On the other hand, Bwalya

(2013) argues that the climatic hazards that Zambia had experienced thus far had severely impacted on agriculture production and food security.

It was also established that rainfall had a positive effect or relationship with the food security indicator (production) while temperature was found to have a negative effect. This showed opposite effects of the two climatic variables. This result or scenario matches with Chi-Chung *et al.* (2004) who established that precipitation and temperature have opposite effects on yield levels of maize in that high rainfall can cause yield levels to rise, and high temperature has a reverse effect on maize production.

However, even though the contribution of climatic factors to production is only 12 percent, this result goes a long way in indicating the importance of climate (rainfall and temperature) in maize production and hence the food security situation in area. These effects on maize production in Choma district provide a corresponding effect on rural household food security as production affects all the four components of food security. An analysis of the two climatic elements reveals that temperature had a stronger effect (11.8 percent) on production as compared to rainfall – whose effect was established to be negligible (0.002 percent). Therefore generally production of the staple crop in the district had gone down due to the strong influence of rising annual temperature, thereby causing rural household food insecurity.

The results have reviewed that the rising annual temperatures have had a remarkable negative effect to production of the maize crop. Ordinarily, during vegetative growth, maize has a maximum response to temperature of between 25 - 30°C and during reproductive growth, maize responds well to temperatures above 12°C (Stewart *et al*, 1997). However, high temperature affects the plant through its effects on the availability of water which is very important in the process of photosynthesis. Thus, with high temperature and strong solar radiation, evapo-transpiration increases (Holmen, 2003), thereby increasing water stress on the plant which reduces maximal photosynthesis and carbon dioxide quantum yield.

The important thing to note however from the findings is that rainfall and temperature did not have a significant effect on production and hence the food security situation in the district. With an R^2 of 11.9 percent, it means annual rainfall and temperature contributed only about 12 percent to the food security situation in the area which is low. The rest, 88 percent of the food security situation is by other factors. The interpretation is clear; there were other factors that affected maize production in the district, and hence the rural household food security. These factors could relate to management practices, the soils, fertilizer among others. Also, another important determinant related to the variables used in the study could be the spread of the rainfall within the year, (Iboteye and Shaibu, 2014). According to Ojo (2000) and IITA (2009), one month drought when maize is tasselling can result into serious reduction in the output of maize. This is especially important because maize needs at least 500mm of well –distributed rainfall during the season. In addition, the impacts of drought on the crops depend on the duration of the drought and the time of occurrence. Prolonged droughts occurring during crop establishment can be very devastating as seedlings die and the plant population is reduced. Furthermore, if droughts occur during flowering, it has an amplified effect on the yield as it severely restricts formation of grains per plant due to impaired pollination or because fertilized ovules stop growing (Edmeades *et al*., 1992). Historical accounts in Zambia show that if droughts occurred in December, January, February and March worse crop yields occur since crops have no chance of growing and maturing. The case is different if the drought occurred in a different time sequence.

Generally, the findings of this study confirm literature on the effect that climate variability and change will have on food production. For example, Belloumi (2014) points out that variability of rainfall coupled with continuing rise in temperature will reduce food production. The results also support earlier studies that have found that global warming is likely to have adverse effects on farm productivity in Africa (Massetti & Mendelsohn, 2011; Kabara and Kabubo-Mariara, 2011; Mohamed et al. 2002; Molua 2008; Molua 2002; Nhemachena et al. 2010). In addition, Parry, Rosenzweig, Iglesias et al. (2004) also found that climate change is likely to lead to declining crop yields and to increase the disparities in cereal yields between developed and developing countries.

This reduction in maize production in the district had affected all the four components of food security. There is a very close relationship between production and household access to the staple. This is so especially that the amount of grain available has a direct bearing on the prices of the Maize grain as well as maize meal. All the households sampled confirmed that the price of both maize meal and maize grains have risen and this especially so towards the end of the year when most households run out of stock up to around February and march when the new crop is ready consumption. Besides this, income in the area, which is a critical component of access, is centered on maize production. Therefore, the reduction in production of maize has negatively affected household income as the households do not have excess maize stock that can be sold. Agriculture is not only a source of food but, equally important, also a source of income. This situation confirms literature by Schmidhuber (2007), who argues that the crucial issue of food security is not whether food is ‘available’, but whether the monetary and non-monetary resources at the disposal of the population are sufficient to allow everyone access to adequate sources of food.

At the same time, this reduction in yields is directly linked to a reduction in household food availability. The households in the area depend largely on what they grow for food and reduced yields means reduced availability. This confirms literature by Thompson et al (2010) who argued that many communities rely largely or solely upon their own subsistence farming for their food needs with marginal groups especially dependent upon climate-sensitive resources making availability the most direct impact of climate change. Availability encompasses things like the amount of food, and it was clear that amount of food has reduced as attested by 77 percent of the sampled households.

The reduction in production has also affected the stability component of household food security. This is because it has affected the principle source of household income and has also reduced the proportion of crop that can be sold by the households. In most instances, the households are forced not to sell anything as this will exacerbate food insecurity. In addition, the low production attributed to the climate situation has increased the number of months of household food shortage as the grown stock cannot sustain the households for longer periods of time.

The other component of food security that has been affected by this low production attributed to climate factors is food quality. This aspect has been affected due to the fact that less maize production means the households are selling less. This means therefore that they do not have enough money to purchase for instance, proteins, or what is called good nutrition. This scenario confirms literature by Thompson *et al* (2010), who argued that protein is especially absent from the diet of much of the population in sub Saharan Africa , with most Africans considered to be protein deficient. A major influence on poor nutrition in the area could be largely attributed to lack of a diversified diet, which is seen to result in a failure to ingest certain essential nutrients. This is so because all the households reported that cereals and greens were at the center of their diet.

5.5 Climate change awareness among rural household in Choma district

5.5.1 Field data on climate change awareness

To establish climate change awareness among rural households in the district, awareness was measured as a dummy variable, meaning the respondents were to give (Yes) and (No) answers. However, due to the complex nature of the concept of climate change, the researcher had to pick whether the evidence given meant climate change or normal weather variations.

Based on the responses and evidences provided, the respondents proved that they were aware of climate change. This is because according to them, the climate had changed. The respondents gave evidence of this change based on their own experiences of the climatic scenarios. The scenarios were based on historical rainfall patterns, with some respondents giving evidences going as far back as the 1960s. Generally, the point from the respondents was that the current rainfall patterns were evidence of climate change. The respondents used a local Chitonga phrase "*Ziindi zyacinca*", literally translated as "the times or the seasons have changed" in their description of the situation.

Thereafter, the respondents were asked to give information on whether they had access to climate change information from four identified sources that were used and the responses and the frequencies are shown in table 5.7.

Table 5.7: Access to climate change information

	RESPONSE FREQUENCIES	
Indicator	**Yes**	**No**
Contact with Meteorological dept.	0	87(100)
Weather information on media	29(33)	58(67)
Climate change information on media	0	87(100)
Climate related extension services	24(28)	63(72)

Key: Figures in parenthesis are frequency percentages

Source: Field data (2015)

The responses show that the respondents had no direct contact with the meteorological department and hence no contact with climate related data. 33 percent of the respondents reported receiving weather information from either radio or television and 67 percent did not have access to this. All the respondents reported that they had not received climate change related information from media (television and radio). With respect to climate related extension services, 28% of the respondents had received the service as opposed to 72 percent.

5.5.2 Discussion on climate change awareness

Overall, this picture shows climate change awareness among the respondents. This awareness was largely based on individual experiences and not out of formal awareness. It is clear that there was lack of formal knowledge on climate change, as there was less institutional or formalized programs on climate change awareness. There was clear absence of extension services focusing on climate change awareness and (Oduniyi 2013, Nhemachena 2007 and Mandleni 2011) have argued that lack of exposure to extension service influences climate change awareness. On the other hand, Odiniyi (2013) argues that extension services provide an important source of information on climate change as well as agricultural production and management practices, and this was found to not be the case in the district.

Therefore, the lack of deliberate institutional efforts aimed at climate change awareness obviously had a bearing on especially adaptation. This is because the more the farmers have access to extension services and information about climate change, the more they adapt to climate change (Luseno, *et al.*, 2003). Hassan and Nchemachena (2008), Apata *et al* (2009), Deressa *et al* (2010) and Bryan *et al* (2009) have indicated that access to extension services had a strong positive influence on adapting to climate change. Nchemachena (2007) also noted that exposure to extension services influences the capacity to adapt to climate change and also increases awareness of climate change.

5.6 Adaptation and coping strategies to climate change and variability

Most of the respondents in the study sites had problems understanding the question of adaptation and coping measures as they mixed both in the responses. Hence the researcher had to pick the responses for each of the measures from the combination of adaptation measures and coping strategies given by the respondents.

5.6.1 Adaptation strategies

5.6.1.1 Field data on adaptation strategies

The sampled rural households in the study area reported having in place strategies they were using to adapt to the food security effects of climate variability and change. As evidenced from their responses provided in table 5.8, there was effort towards adapting and three (3) adaptation strategies were evident from their responses. However, these responses were not mutually exclusive as some households provided more than one adaptation strategy. It is important to note that the main driver of these strategies according to the respondents was rainfall deficiency.

Table 5.8: Households adaptation measures

Adaptation Strategy	Frequency	Percentage
Use of early maturing hybrid seed varieties	36	41
Use of drought resistant crops	02	2
Use of conservation farming	13	15
Growing whatever is available	51	59

Source: Field data (2015)

Generally, what is evident from the table is that 41 percent of the households had adopted some adaptation mechanism while 59 percent had not. From the table, 41 percent of the households were using hybrid seed varieties of maize and this was found to be the dominant adaptation strategy being used. These seeds were accessed through the Farmer Input Support program (FISP), although some households reported buying them straight from retailers. Among the reasons provided for use of these seeds were that they were drought tolerant, high yielding and early maturing. Secondly, in addition to use of hybrid seeds 15% of the respondents reported employing conservation farming methods on small plots. This they said was being promoted by the Conservation Farming Unit. A paltry 2 percent of the same respondents reported having had planted drought resistant crops, and these are sorghum and sunflower. However, majority of the respondents (59 percent), reported that they had not employed any adaptation strategies and where planting anything available as long as the onset of the rains arrived. What was evident was that since all the households in the study site cultivated maize, most of their adaptation measures centered on maize growing.

5.6.2 Coping strategies

5.6.2.1 Field data on coping strategies

The sampled households reported a number of coping strategies they have employed to survive the food security effects of climate variability and change. What was clear is that all the households had in one way or another adopted some coping strategy. These strategies mainly centered on diversification of activities and it was clear that they had become multi-active from their responses. The activities mentioned include charcoal production, providing casual labor in commercial farms as well as doing various forms of piece work. All these were said to provide some income which the households would use to buy food.

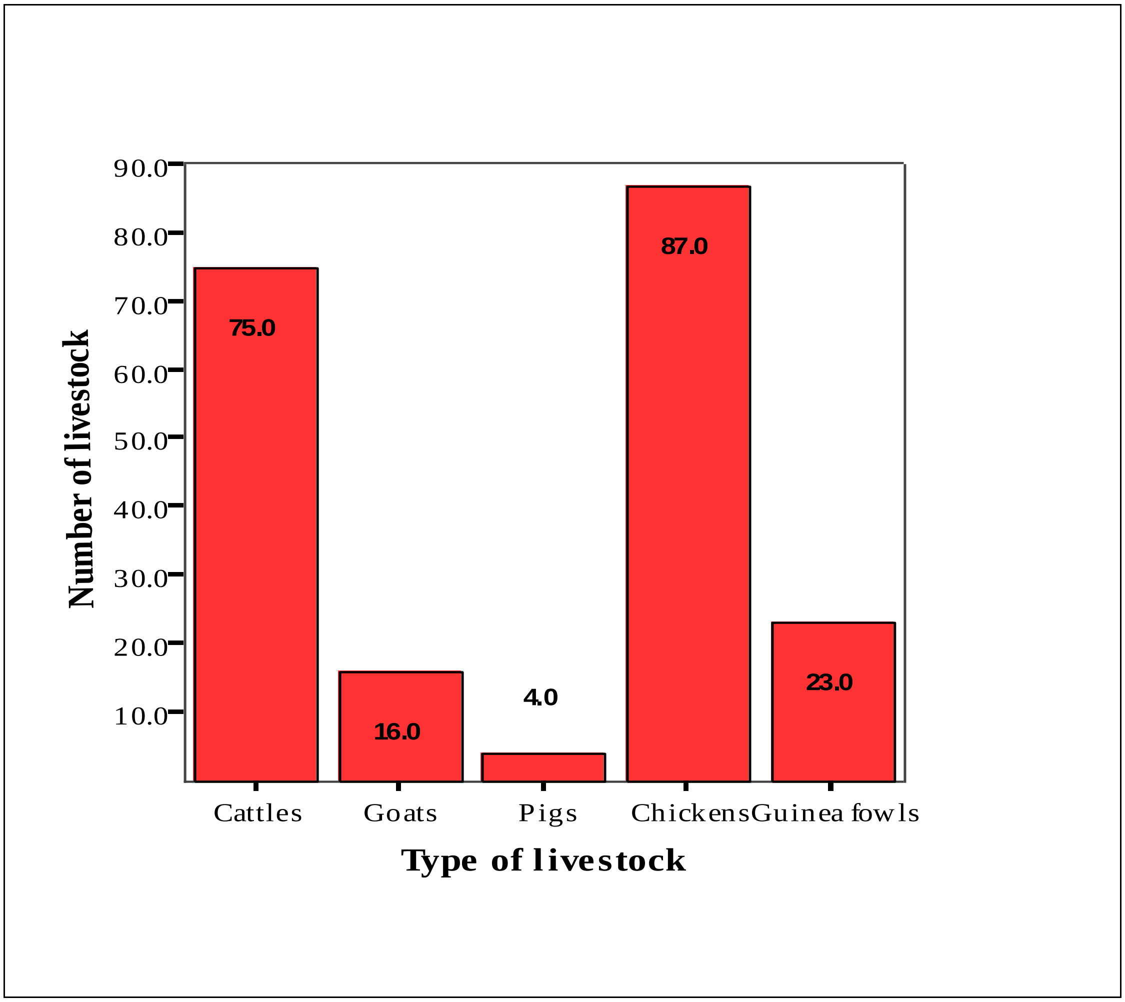
In addition, supplementary and complementary crops were reported to be grown by the households to provide the households with sustenance during the periods when maize does not do well as they could sell these crops for income. Such crops include sweet potatoes, groundnuts, pumpkins and okra. On the other hand, some households also own gardens near streams (those lucky to be near streams) and they not only did gardening during the dry seasons but these gardens also provided backup to maize during the periods when maize does not do well. These gardens were reported to be used usually to cultivate vegetables (shown in plate 5.1) which were sold for cash used for a variety of household needs, especially purchase of maize meal during seasons when maize did not do well.

Plate 5.1: Vegetable garden in Singani

Source: Field data (2015)

Other coping strategies that were reported to be employed by the households in cases of crop failure include income diversification through such activities like brewing beer for sale, buying and selling of “Chibuku beer” brand, selling crafts, selling livestock like chicken and goats together with livestock products like milk. In extreme cases, some households reported that they had to sell cattle to raise money to buy food. Some important livestock kept by the respondents which were said to be a source of income for buying food are indicated in the figure 5.7.

Figure 5.6: Livestock kept by the rural households



Source: Field data (2015)

From figure 5.6, it is clear that chickens and cattle are very important forms of livestock being kept by the sampled households. In times of food shortage, these are very important as a means of exchange either for income to be used to buy food (largely maize meal or maize grain) or they are directly exchanged with food in order for the household to survive.

5.6.3 Discussion on adaptation and coping strategies

There was evidence of effort by the rural households to adapt to and cope with the food security effects of climate variability and change. With regard to adaptation, the strategies employed related to some of the proposed adaptation measures by GRZ (2007) to various climatic hazards, particularly use of hybrid maize varieties and conservation agriculture. These findings also relate to Wineman and Mulenga (2014), who found that adoption of new seed varieties and conservation agriculture seemed to be a widely recognized toolbox of potential responses to climate change the district. The hybrid seeds are used for a number of reasons, but more importantly for being drought tolerant, early maturing and high yielding. It is recognized that conservation agriculture helps to conserve not only soil fertility and organic matter but it also conserves soil moisture making it one of the alternatives to sustainably adapting to impacts of climate variability and change such as droughts.

In addition, these findings on adaptation strategies relate to those by (IFPRI, 2013 and Kalinda 2011) especially on the fact these adaptation strategies are largely a response to decrease in precipitation and that some people in rural areas have not adopted any adaptation strategies, as the case was found to be among some households. In addition, like this study, these studies found increased diversification through engaging in production activities that are more drought-tolerant and or resistant to temperature stresses as well as activities that make efficient use and take full advantage of the prevailing situation water serve as an important form of insurance against rainfall variability. However, adaptation efforts to the effects of climate variability and change in the study area were still low. It was evident from the respondents that they lacked knowledge as well as the capacity to adapt.

With regard to coping strategies, GRZ (2007) confirms the coping strategies to the food security effects of climate variability and change identified in this study. This report asserts that households cope by diversifying their sources of income and relying more heavily on alternative natural resources from forests and wetlands and these finding collaborate of this report on main coping strategies used by different communities to combat the major impacts of climate change and variability. Some of the coping strategies identified by this report were, income diversification (e.g. charcoal burning), trading in other commodities for food, selling less crops, among others.

CHAPTER SIX
SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This section summarizes the major findings of this study and provides the conclusion and recommendations. The findings are described under the thematic areas contained in the study objectives and the recommendations are based on the conclusions derived from the study.

6.2 Summary of key findings

6.2.1 Climatic trends in Choma district

The first objective of this study sought to examine the climatic trends in the district from 1976 to 2014. The climatic elements examined were mean annual rainfall and temperature. Mean annual rainfall was found to have exhibited inter annual variations during the period with fluctuations of both high and low. The general long term trend for rainfall was found to have been fairly steady during the period indicating that there had been no major change in rainfall activity in the district during the period under review. Instead, it was found that the usual seasonal variations of high and low rainfall characterized the period. Mean annual temperature on the other hand, like rainfall, showed variations, with fluctuations of both high and low annual temperatures. However, with regard to the long term trend, it was found that there was a rising trend in this climatic element during the period. This rising trend was an indication that temperature in the district was rising.

6.2.2: Rural household food security situation in Choma district

The second object sought to establish the rural household food security situation in Choma district. The food security indicators used in the study were district level production of the staple (maize), period of household food shortage and households' perception of their food security situation. With these indicators, it was established that majority of the rural households faced food insecurity, though the situation was fluid as it depended on seasonal crop performance. A few households however, were found to be secure. With regard to the district level production indicator for instance, it was found that production had varied during the period under review, characterized by episodes of high and low seasonal production. Because of the close link between production of the staple (maize) and rural household food security in the district, the food security situation could be said to have as well fluctuated, with high production improving the situation and low production causing insecurity. Generally, the study found that there was no evident long term trend in production to show a specific bias towards either rural household food security due to increased production or insecurity due to a falling trend in production. Instead the situation was characterized by inters annual fluctuations.

In terms of the period of household food shortage, the study found that 78 percent of the rural households in the district experienced months of food shortage. It was established that these households were food secure three to four months after harvest. Thereafter, they faced food shortage and had to rely heavily on purchase of both maize grain and maize meal, while at the same time depending on relief food as well as food for work especially in commercial farms. The reason for the shortage was that the quantity of the yield from their crops was not sufficient to last longer.

In terms of households' perception of their food security situation, the study found out that all the households were increasingly becoming worried of their food security and further described the situation as being insecure for their households. This was attributed largely to production of the staple crop which was described as having gone down as well as to the prices of the staple (both maize grain and maize meal) which had continued to rise posing a serious risk to household food security.

6.2.3 Effect of the climatic situation on rural household food security in Choma district

The third objective of the study sought to determine the effects of the climatic situation in the district on rural household food production, and hence rural household food security. Multiple regression analysis was used to establish this. The analysis showed that mean annual rainfall and temperature accounted for 12 percent of the variations in rural household crop production, and hence, rural household food security. More specifically, the effect was found to be positive for rainfall while temperature was found to have a negative effect. The positive effect for rainfall means that it had led to increased production while the negative relationship for temperature means it had led to reduction in production, thereby providing corresponding effects to rural household food security. An analysis of the two climatic elements reviewed that temperature had a stronger effect (11.8 percent) on production as compared to rainfall – whose effect was established to be negligible (0.002 percent). Therefore generally production of the staple crop in the district had gone down due to the strong influence of rising annual temperature, thereby causing rural household food insecurity.

The third objective also sought to establish whether the relationship between climate variability and change (climatic situation) with rural household food security was significant. Therefore the study tested the null hypothesis which negated the existence of a significant relationship between climate variability and change and rural household food security. Rainfall and temperature where the dependent variables while district level maize production was the dependent variable in the multiple regression analysis. The analysis showed that both rainfall and temperature were not significant at alpha level 0.05. Therefore, there was not enough evidence to reject the null hypothesis. In addition, the contribution of both to production as indicated by R^2 is 12 percent which is low. On the basis of this analysis, it was concluded that climate variability and change did not have a significant relationship with the rural household food security situation in Choma district. In other words, climate variability and change were not significant determinants of rural household food (maize) production and hence the rural household food security situation. Instead, the rural household food security situation in the district was largely on account of other factors outside of mean annual rainfall and temperature.

6.2.4 Climate change awareness among rural households in Choma district

The fourth objective sought to establish if the rural households in Choma district were aware of climate change. Overall, it was found that the respondents sampled were all aware of climate change. However, the knowledge of climate change was found to be informal, as it was based on individual experiences. It was also found that there was generally luck of deliberate initiatives and programs at institutional level aimed at climate change awareness for the rural household. This scenario could have affected the adoption of climate change adaptation strategies.

6.2.5: Adaptation and coping measures to the food security impacts of climate variability and change

The last objective of the study sought to identify the coping and adaptation measures adopted by the rural households to mitigate the potential food security effects of climate variability and change. Adaptation was found to largely be based on planting of early maturing maize varieties (41 percent), while few households practiced conservation farming (15 percent) and others planted drought resistant crops like sunflower. However, more households (59 percent) had not applied any adaptation measures. With regard to coping measures, it was found that the households were largely diversifying their income sources as a way of earning incomes that would improve their food purchasing power.

6.3 Conclusion

Based on the findings of this study, Choma district was experiencing climate variability and change characterized by a rise in annual mean temperature while rainfall had remained fairly steady during the period (1976 – 2014). There was also a relationship between the climatic situation in the district and production of the staple crop (maize), upon which household food security is founded. The rural household food security situation in the district had been negatively affected by the rising trend in temperature while rainfall largely had no effect. However, their effect was not significant, such that the rural household food security in the district was largely affected by other factors not included in the study.

On the other hand, rural households had employed some strategies to mitigate against the food security effects of climate variability and change. These were in the form of adaptation strategies that was mainly through planting early maturing maize varieties while coping was mainly through diversification of income sources which necessitated purchase of food during periods of shortage. These measures were partly because the rural households were aware of climate change.

6.4 Recommendations

In order to effectively deal with this minimum contribution of mean annual temperature and rainfall on rural household food security, the study recommends the following:

6.4.1 Recommendations to policy makers

- There is need for Ministry of Agriculture through its extension services and other agricultural organizations to encourage the rural farmers especially in traditionally maize communities (like Choma district) to begin to adopt other crops that may perform well under the current climatic conditions as opposed to reliance on maize even when it may not be performing well. Crops such as sorghum, millet, cassava and sunflower should be encouraged. This should be in addition to encouraging the households to grow variety so that they have what to rely on when one crop fails.

- There is need to identify the poor and vulnerable rural households for proper targeting of climate variability and change policy strategies. This is because rural households are heterogeneous in terms of their natural, social, financial, physical, and human capital asset endowments. This means that the food security effects of climate change and variability are not the same among rural households.

- The rural households must be encouraged to adopt modern agricultural productivity enhancing technologies. To do this, government and its development partners must invest in agricultural modernization (like conservation farming) including construction of irrigation facilities in rural areas. There is need to increase the agricultural land under irrigation and introducing water saving techniques for maize production.

- The government through Ministry of Agriculture and the Meteorological Department together with cooperating partners should invest in disseminating accurate knowledge about climate change to the rural households in order for them to know formally what climate change is all about and what impact it has on their farming activities. A proper education will bring about an increase in their level of awareness. Farmers should be equipped with knowledge on climate change, vulnerability and the adaptation measures that would help them in their faming activities.

- There is need for the Meteorological Department and its cooperating partners to work on strategies that will improve on appropriation of climate and weather data in rural areas.

This should be coupled with improvement in early warning systems for farming households to prepare themselves for forthcoming farming seasons.

6.4.2 Recommendations for future Research

In terms of future research, comprehensive and in-depth studies on climate variability and change impacts on rural households in Zambia and how communities cope with and adapt to related stresses are still not many. To address this matter, future research should aim at answering questions such as:

- How has climate variability and change affected the food security situation of rural communities across the three agro-ecological regions in the country?
- What climate variability and change adaptation and coping strategies are feasible to the rural communities in the three agro-ecological regions of the country?

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APPENDIX

APPENDIX 1A: Questionnaire used on the households

For Interviewer:

Interview No.	
Name of interviewer	
Language used in interview	

Introduction

This questionnaire seeks to obtain information on the implications of climate change and variability in Zambia: Experiences from rural households in Choma District, Southern Province.

This interview is entirely anonymous. No one will know your name and so you may speak quite freely to the interviewer. We thank you for your time and assistance in our work.

1.0 General Information/Household Bio-data

1.1. Please indicate where the interview is taking place, for example, the name of the village or settlement.

……………………………………………………………………………………………………..

1.2. How long have you lived in this area?

………………………………………………………………………………………………………

1.3. Sex

MALE	FEMALE

1.4. What is your age?

21 - 30	
31 - 40	
41- 50	
51 – 60	
61 – 70	
Above 70	

1.5. What is the size of the household?

…………………………………………………………………………………………………

1.6. What is your main occupation?

…………………………………………………………………………………………………

1.6. What is your education level?

…………………………………………………………………………………………………

2.0 Food security situation in the area

2.1. What is your basic diet and do you produce your own food?

…………………………………………………………………………………………………

2.2. How many meals do you have per day?

…………………………………………………………………………………………………

2.3. Do you have this number of meals throughout the year?

…………………………………………………………………………………………………

2.4. Do you have enough food for the family?

…………………………………………………………………………………………………

2.4. Have you faced shortage of food in the past? When? For how long? How bad?

……

2.4. If answer to 2.3 is yes, how has your household dealt with the food shortage?

……

2.5. What is the monthly income for your household?

……

2.6. When you look at the prices of food (e.g. mealie meal, maize, sweet potatoes etc.), is the price manageable for the family?

……

3.0 Nature and trends of climate variability and change

3.1. Have you observed any major changes in the climate/weather patterns in your area (village, province) over the past years or decades? E.g., has the temperature or rainfall increased, decreased or there has been no change?

……

3.2. What has been the situation in your area in terms of extreme climatic events like floods and droughts? How would you describe the incidences of these in your area?

……

3.3. According to your observation, how would you describe the number of rainy days in your area? Have they increased, decreased or there has been no change?

……

3.4. Have you observed any changes in your environment that are potentially linked to changes you mentioned above? E.g., in forest cover, pasture land, agricultural land, streams/rivers wildlife, or any other change.

……

4.0 Impact of climate variability and change on rural household food security

4.1. In a season, how much food/cereals do you produce?

…………………………………………………………………………………………………

4.2. In the past years, do you think your agricultural yields have increased, decreased or they have remained the same? And what is the reason for that?

…………………………………………………………………………………………………

4.2 Do you think the climate situation has affected your agriculture?

…………………………………………………………………………………………………

4.3. In your view, has the food security situation in your household been affected by these climatic changes? And if so, how?

…………………………………………………………………………………………………

4.4. According to you, what weather extremes have impacted your household food security? Is it unpredictable weather? Floods? Droughts? Others, including positive impacts? If available, could you please provide information on magnitude of losses?

…………………………………………………………………………………………………

4.5. Historically, did you have any problems related to food that were caused by similar factors we talked about? – three decades ago or more? Please give details if possible.

…………………………………………………………………………………………………

4.6. In cases when there is no food (cereals, mealie meal etc.) in your home and you have to buy, where do you buy from and is distance of any impact to you when you look at going to the place you have mentioned to buy food?

…………………………………………………………………………………………………

5.0. Local Awareness and Perception of Trends Related to Climate Change

5.1. Do you think the climate is changing?

……………………………………………………………………………………………………

5.2. If the answer to 5.1 is yes, what do you think is the reason for this change? If answer to 5.1 is No, why do you say so?

……………………………………………………………………………………………………

5.3. Is there any awareness being made in your area on climate change and if so in what form?

……………………………………………………………………………………………………

5.4. Does climate related information from the Zambia Meteorological Department reach you?

……………………………………………………………………………………………………

5.5. Do you receive climate related information on media platforms such as Radio and Television?

……………………………………………………………………………………………………

5.6. Are there any organizations in your area that come to sensitize you about climate change?

……………………………………………………………………………………………………

5.7. Do agricultural extension officers include climate related lessons during their field visits to your area?

……………………………………………………………………………………………………

5.8. Are you aware that there is a phenomenon now called climate change?

……………………………………………………………………………………………………

6.0. Adaptation and coping strategies

6.1. What measures you are using to deal with changes in temperature and rainfall patterns as regards your agriculture?

………………………………………………………………………………………………………

6.2. Do you have any strategies for multiplying crops? If so, what are they?

………………………………………………………………………………………………………

6.3. Do you have other means for increasing family income?

………………………………………………………………………………………………………

6.4. To ensure that your household is food secure, what is it you are doing?

………………………………………………………………………………………………………

6.4. In conclusion, what possible solutions or suggestions do you propose for enabling the common people to cope with climate changes and food security in their homes?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………

THANK YOU FOR YOUR VALUABLE TIME AND YOUR PARTICIPATION IN THIS IMPORTANT RESEARCH PROJECT.

APPENDIX 1B: Semi-structured interview schedule used on key informants

Personal Information:

1. Name…………………………………………………………………………………….
2. Position………………………………………………………………………………….
3. Contact details…………………………………………………………………………

1.0 Information on Climate Change

1.1 Do you think Zambia and in particular Choma district is experiencing Climate Change?

…………………………………………………………………………………………………

1.2 Why do you say so?

…………………………………………………………………………………………………

1.3. If yes, for how long has this problem been?

…………………………………………………………………………………………………

2.0 Household food security situation in the district

2.1 How would you describe the household food security situation in the district/area? Do they still have enough food or not?

…………………………………………………………………………………………………

2.2. When you look at the incomes of the rural households and the food prices, would you say access is guaranteed for the households in this regard? Please explain

…………………………………………………………………………………………………

2.3. Has your organization received any information of food shortage from the rural parts of the district? Approximately for how long are the shortages?

…………………………………………………………………………………………………

3.0 Impacts of climate change and variability on household food security

3.1 Has food production in the district been affected by climate change and variability and to what extent?

……

3.2. Can you say whether or not the household food security situation has been affected by climate change and variability in the rural parts of the district? Explain how

……

3.2. What aspects of climate change and variability have impacted food security in this area? Is it floods? Drought? Others, including positive impacts? If available, could you please provide information on magnitude of losses?

……

3.4. According to you, how has/have the climate aspect(s) you have mentioned affected rural household food security?

……

4.0 Climate change awareness, coping and adaptation

4.1 In your opinion, would you say people in the rural areas are aware of climate change? Why do you say so?

……

………………………………………………………………………………………………………..

4.2. Are there any deliberate efforts to educate households in the rural parts of the district on climate change? You can include names of institutions involved if any.

……

4.3. What climate change adaptation and coping measures is your department promoting and have they been effective?

……

4.4. In light of the climatic situation, what is your department doing to improve the rural household food security situation?

……

4.5. Finally, what has been the government's response to these problems of climate changes in the district?

……
……

End of Interview. Thank you so much for giving me you time Sir/Madam

APPENDIX 2: Panel data used in the correlation and regression analysis

YEAR	PRODUCTION (MT)	RAINFALL (mm)	TEMPERATURE (^{0} C)
1976	18,045.63	437.1	18.8
1977	74,257.2	1,147	19.75
1978	10,800	660.7	19.1
1979	29,103.3	1,066.8	19.15
1980	54,000	930	19.05
1981	130,575	550	18.9
1982	51,705	626.5	19.8
1983	43,605	527.1	20.2
1984	39,092.76	841.9	19.6
1985	74,793.06	1,047	19.35
1986	107,743.1	711.9	19.15
1987	52,217.46	719.9	20.5
1988	97,558.74	1,017	19.55
1989	97,638.93	891.2	19.8
1990	51,102	598.4	20.2
1991	38,261.79	506.6	19.45
1992	3,182.04	791.3	20.5
1993	105,822.9	537.3	20
1994	39,103.29	410.5	19.7
1995	8,540.19	928.6	20.65
1996	61,893	1,080.6	20
1997	37,677.87	673.7	20
1998	52,546.5	747.1	20.45
1999	****	874.1	19.7
2000	43,699.59	901.9	19.75
2001	31,578.03	625	20.65
2002	24,599	681	20.55

YEAR	PRODUCTION (MT)	RAINFALL (mm)	TEMPERATURE (^{0} C)
2003	3,264	954.1	20.3
2004	27,997	524.9	20.7
2005	52,931	856.6	21.1
2006	51,949.87	932.9	21.1
2007	13,913	1,035	20.4
2008	47,413	861.6	19.9
2009	63,818	886.9	20.15
2010	100,268	826.2	****
2011	110,156	715	****
2012	88,100	851.7	****
2013	94,530	670.1	****
2014	66,171	773.8	****

**** Indicates Missing data