Implication of climate change on livelihood and adaptation of small and emerging maize farmers in the North West Province of South Africa.

by

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DEDICATION

I would like to dedicate this thesis to my late mother, Esther Oduniyi and my lovely family, Oluwademilade and most importantly Nelsi.

DECLARATION

I, Oluwaseun Samuel Oduniyi, declare that "IMPLICATION OF CLIMATE CHANGE ON LIVELIHOOD AND ADAPTATION OF SMALL AND EMERGING MAIZE FARMERS IN THE NORTH-WEST PROVINCE OF SOUTH AFRICA" is my research work and that the sources I cited are referenced. The work has not been submitted before for any degree or examination at any other university.

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ABSTRACT

Climate change implication and rural livelihood capitals remain the major inextricable dimensions of sustainability in this twenty first century globally. As a result, the impact and outcome of climate change on rural livelihood capitals, including economic development cannot be overemphasized in Ngaka Modiri Molema District Municipality of the North West Province of South Africa, where the study took place. It is one of the largest maize production regions in South Africa, where a preponderance of the people in the province obtain their livelihood from agriculture which contributes enormously to the promotion of household's food security. The study, therefore, investigated the adaptation strategies, awareness of climate change, factors that influenced climate change adaptation in North West Province of South Africa, with the aim of ascertaining the effects of climate change on livelihood capitals among small and emerging maize farmers.

Stratified random sampling technique was used to select three hundred and forty-six (346) farmers who were interviewed from the study area, while a pre-tested questionnaire was administered to the maize farmers, aiming at matters related to climate change impact on livelihood and adaptation. Data were analyzed using descriptive statistics while inferential statistical tools employed were Principal Component Analysis, Two-Stage Least Square regression model, Binary Logistic regression model, and Tobit regression model.

The results of the study showed that climate change was linked to rural livelihood capitals as climate change awareness, low profit and co-operative finance were statistically significant ($p<0.05$). The study also established that majority of the rural farmers in the study area were aware of climate change, in which farm size, education, ownership of the farm, information received on climate change, source of climate change information, climate change information through extension services, channel of information received on climate change and support received on climate change were statistically significant ($p<0.05$). Factors such as farm size, household gender, type of farms, who owns the farm, land acquisition, source of climate change information, support received on climate change, and adaptation barrier were statistically significant ($p<0.05$) and influenced climate change adaptation in the study area.

Conclusively, climate change is entwined with rural livelihood, and the variables that are significant to the study were identified. It was therefore recommended that government

intervention, access to information, extension service and support, farmers' networking, adoption of drought and heat stress tolerant seeds, indigenous knowledge should be improved, practiced and promoted among the rural farmers and the stakeholders involved in the study area.

Key words: *Climate change awareness and adaptation, livelihood capitals, maize production, binary logistic model, Tobit regression model, 2SLS model, North West Province.*

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

CHAPTER TWO

LITERATURE REVIEW

CHAPTER THREE

RESEARCH METHODOLOGY

CHAPTER FOUR

SOCIO-ECONOMIC CHARACTERISTICS OF FARMING HOUSEHOLDS AND ADAPTATION MEASURES

CHAPTER FIVE

CLIMATE CHANGE AWARENESS IN THE STUDY AREA

CHAPTER SIX

CLIMATE CHANGE ADAPTATION AND THE INFLEUNCING FACTORS AMONG THE FARMERS IN THE STUDY AREA

CHAPTER SEVEN

THE EFFECT OF CLIMATE CHANGE ON FARMERS' LIVELIHOOD CAPITALS

CHAPTER EIGHT

SUMMARY, CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

BFAP	Bureau for Food and Agricultural Policy
BLR	Binary Logistic Regression
CA	Conservation Agriculture
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Centre)
CSA	Climate Smart Agriculture
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DFID	Department for International Development
ECA-SA	Economic Commission for Africa Sub-regional Office for Southern Africa
EEA	European Environment Agency
EPA	United States Environmental Protection Agency
EPIC	Erosion Productivity Impact Calculator
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GHG	Greenhouse Gases Emissions
GSA	Grain South Africa
ICID	International Commission on Irrigation and Drainage

IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Developed Countries
LRAD	Land Redistribution for Agricultural Development
NDA	National Development Agency
NRC	National Research Council
NWDC	North West Development Corporation
OECD	Organization for economic co-operation and development
OLS	Ordinary Least Square
PCA	Principal Component Analysis
SADC	Southern African Development Community
SAGIS	South African Grain Information Service
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
TSLS	Two Stage Least Square
UN	United Nations

UNECA-SA	United Nations Economic Commission for Africa Sub Regional Office for Southern Africa
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund.
USGCRP	United States Global Change Research Program
VIF	Variance Inflation Factor
WMO	World Meteorological Organization
WWAP	World Water Assessment Programme

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

Climate change is one of the environmental problems experienced by mankind. The implication of climate change cuts across various sectors, ranging from health to agriculture. Studies have shown that climate change and agriculture are two entities that cannot be separated; however, their interaction has resulted into a negative impact on agricultural production and livelihood. According to Ochieng *et al.* (2016), climate change has menacingly affected global agriculture in the 21st century. Moreover, its effects on agricultural production and livelihood are expected to intensify over time, and to vary across countries and regions (FAO, 2016). Correspondingly, Chambwera and Stage (2010), stated that climate change could impair economic growth.

Equally, climate change has become an imperative challenge facing African countries, while the impact is largely due to little revenue, more dependence on climate-sensitive sectors such as agriculture, and the lack or poor ability to get acclimatized to the changing climate (Belloumi, 2014). Likewise, there is a collective confirmation that climate change will intensely affect the African continent and will be one of the thought-provoking concerns for future growth, particularly in the arid regions (Huq *et al.,* 2004; Kurukulasuriya and Mendelsohn, 2006). On the word of James and Washington (2013), temperatures in all African countries are estimated to rise faster than the global average increase during the 21st century. Subsequently, the African continent is anticipated to be the utmost affected and susceptible to the effects of climate change (Hummel, 2015; Bewket, 2012).

Relatedly, climate change is usually linked to global warming, which is a term that denotes a gradual rise in the average temperature of the earth's atmosphere. Global warming has been described as a state of consistent increase in temperature. Accordingly, Mandleni (2011) climate change is occasionally referred to as global warming because of the increasing temperatures encountered across the earth. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) indicated that the increase in greenhouse gases (GHG) emissions has

led to an increase in average temperatures by 0.74 ºC since 1901 and this has caused a rise in the global warming. Patently, the United States Environmental Protection Agency (2014), evidenced that the most effective of the GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_20). Consequently, stakeholders have now taken cognizance of the verity of climate change. Besides there is emerging confirmation that climate change poses a massive menace especially in developing and poor countries (Rose, 2015; Singh and Purohit, 2014).

The agricultural sector is sensitive to climatic conditions, and it has become one of the most susceptible sectors affected by the menaces and effects of global climate change. Notwithstanding its huge contribution to the economy as a whole, it has been facing constant and earnest challenges of many factors. Instances are climate-related disasters like floods and drought, and are notably the major ones; invariably, climate variability and change adversely affects agricultural sector and the situation is anticipated to exacerbate in the future (Ochieng *et al.,* 2016; Organization for economic co-operation and development (OECD), 2015).

It is a palpable fact that the impact of climate change on livelihood is a consistent occurrence, which is a means of making or earning money to make a living. For instance, Nhemachena and Hassan (2007), divulged that agriculture provides livelihood directly or indirectly especially for the rural people because it functions as a source of living for most of the inhabitants in the developing countries. On account of this, farming production remains a key source of income and maintenance for many in the rural communities of developing countries including Africa (FAO, 2003), an evaluation which is equally validated by Kydd and Dorward (2001) and Tetteh *et al.* (2014). They submitted that majority of the poor people in the world live in rural areas and are consequently sustained by agriculture, as farmers or agriculturally related occupations. Similarly, IPCC (2001), averred that climate change impacts are known to be especially severe in nations situated in tropical Africa that rely on agriculture as their main source of livelihood.

Congruently, Ziervogel and Polly (2010), noted that Southern Africa is anticipated to encounter an increase in temperatures and a disruption in rainfall patterns, coupled with an increased occurrence of extreme climate events such as drought and floods owing to climate change. Subsequently, residents of sub-Saharan Africa, South Africa inclusive, are susceptible to climate

change and variability due to a high increase in temperature resulting in frequent incidents of drought, shortage of underground water, scarcity and spatial variability of rainfall pattern (Nhemachena, 2008). Davis *et al.* (2016), confirmed that South Africa has been experiencing an increase in warmer days and more decrease in the number of cooler days. Compatibly, the National Department of Agriculture (2011), ascertained that the average annual rainfall of 450mm per year to be extremely below the world's average of 860mm, while vaporization is relatively high.

It follows that the higher temperature is expected to increase crop heat stress and evapotranspiration demand in North West Province of South Africa. Then, the impacts are expected to affect natural resources such as air and water, which are considered to be the most critical factor associated with climate change. According to Linus *et al.* (2014), it was reported that between 1960 to 2050 the air temperatures in South Africa are anticipated to rise by 2°C on average, while atmospheric carbon-dioxide levels are projected to increase by about 235 ppm (from 315 to 550 ppm). A report by Kiker (2015), on climate change synthesis as regards vulnerability and adaptation assessment, revealed that South Africa including North West Province is experiencing climate change which affects the water and air required by crops for survival. Still, Blignaut *et al*. (2009), avowed that North West is considerably warmer with evidence that the future temperature will increase than normal which could make the region susceptible to mark reductions in maize production.

From the foregoing, it is obvious that adaptation strategies are needed as tools necessary for the advancement of livelihood in the rural communities. Some coping mechanisms must be utilized so as to adapt to climate change. However, in recent years, the capacity to acclimatize to climate change adaptation and mitigation has been limited, which consequently has become a crucial concern to agriculturists, researchers, and policymakers (Benedicta *et al*., 2010). Adaptation to climate change denotes an alteration in natural or human systems in response to verified or projected climatic stimuli or their effects, which lessens harm or maximally utilizes advantageous opportunities (IPCC, 2001; Smit *et al.,* 2000). Analogously, Kurukulasuriya and Mendelsohn (2006), described adaptation as one of the policy options employed to reduce the harmful impact of climate change. Adaptation to climate change necessitates that farmers should first perceive its diverse instrumentations and manifestations, after which they can then recognize suitable adaptations and practice them (Maddison, 2006).

1.2 Problem statement

Existing researches have shown that Africa is particularly vulnerable to climate change (Bewket, 2012; Hummel, 2015; Ochieng *et al.,* 2016), while the vulnerability is as a result of poor level of economic growth, which consequently has led to low capacity to adapt to the impacts of climate change. Subsequently, climate change significantly affects rural communities, especially in South Africa, where a large number of the inhabitants rely on agriculture for their livelihood (Alam *et al.,* 2011; UNFCCC, 2011). It was reported that climate change is identified in the context of other developmental stress such as poverty, low food production, to mention just these (FAO, 2006). Equally, several studies conducted in the African countries have registered a negative upshot of climate change on farming (Sultan and Gaetani, 2016). The challenge is that climate change threatens livelihood, as climate variability destroys farm produce in the study area.

Livelihood capitals among farmers are affected as a result of negative impacts of climate change. Accordingly, in the rural areas of North West Province, the dependency of most people on agriculture has generated into a high level of poverty. This is because weather events and climate affect the lives and livelihood of millions of poor people (IPCC, 2012b). Again, according to Osbahr *et al.* (2008), societies who rely on resources from nature like agriculture in developing countries are facing increased pressures linked to global climate change. The challenge here is that environmental and social consequences of climate change put livelihood at serious risks of hunger, poverty, low farm income and make it more difficult to decrease the percentage of people living in extreme poverty, coupled with the truth that changes in the rainfall pattern greatly affect biodiversity as well.

That agriculture is one of the major backbones of South Africa's economy where production of maize is common in most provinces of the country cannot be gainsaid. Notably, North West Province is one of the largest maize producers in the country (The South African Agricultural Baseline, 2011). South African Grain (2015), reported that the country was compelled to import 934,000 metric tons of yellow maize, which was worth about $137million at current international prices, from countries such as Argentina and Ukraine in 2015 spanning through the end of March, 2016 as drought reduced the maize yield. Feyssa and Gemeda (2015), substantiated that climate change affects the rain-fed agricultural system in technological and economically less developed

countries in Africa. Therefore, there is no gainsaying that the examination of the adaptation measures that farmers need to employ in order to cope with climate change so as to fully maximize the production of maize which is a staple food in North West Province of South Africa becomes necessary.

A perusal of existing literature evinced that there is little scientific knowledge on the effect of climate change on livelihood in the North West Province, considering the continuous and constant upsurge of the unpalatable impacts tailgating climate change, especially experienced among the small scale farmers in the study area. This is despite the contribution of the province to ensure a total maize production in the country. Consequently, it is apparent that more precise and current studies are needed to establish the effect of climate change on rural livelihood, in addition to adaptation strategies that address the negative effects of climate-driven changes.

It is therefore apparent that rural livelihood is adversely affected by climate change, which has resulted into socio-economic problems, which manifest in the form of poverty, hunger, low income, low food production, unemployment, etc. A major drawback on a national level is the lack of research findings to integrate activities, policies and agricultural practices to improve rural livelihood. Consequentially, this study is intended to fill the noted gap by examining the impact of climate change on rural livelihood in the North West Province, not only to append existing literature, develop policy measures, agricultural practices, but also to proffer a plausible framework to improve rural livelihood, besides contributing to the body of knowledge. Thus, there is a need to study the effect of climate change on livelihood and adaptation strategies among small scale maize farmers.

1.3. Research questions

The research questions informed by the problem statement are:

i) What are the socio-economic characteristics of the respondents?

ii) What are the climate change adaptation strategies used by the target farmers in the study area?

iii) Are the respondents aware of climate change and its effects?

iv) What are the factors that influence climate change adaptation among the farmers in the study area?

v) What is the effect of climate change on farmers' livelihood in the study area?

1.4 Research objectives

The overall objective of the study is to determine the effect of climate change on livelihood capitals among small and emerging maize farmers in the North West Province of South Africa. The specific objectives of the study are to:

i) Analyse the socio-economic characteristics of the respondents.

ii) Identify climate change adaptation strategies of the target farmers in the study area.

iii) Determine the awareness of climate change among the respondents.

iv) Identify factors that influence climate change adaptation among the farmers in the study area.

v) Analyse the effect of climate change on farmers' livelihood in the study area.

1.5 Research hypotheses

The following hypotheses were set for the study, in their null forms (H_0: β=0):

(i) There is no significant relationship between respondents' socio-economic characteristics and their level of awareness of climate change.

(ii) There is no significant relationship between respondents' socio-economic characteristics and climate change adaptation.

(iii) There is no significant relationship between respondents' socio-economic characteristics and their livelihood in the study area.

1.6 Motivation for the study

The effects of the activities of climate change on the future of agriculture have become a marked global concern, including South Africa. These marked influences range from extreme heat waves, drought, changes in weather patterns, floods to low rainfall and increased temperatures, amongst many others. As detailed by IPCC (2007), the detrimental after effects of climate change have resulted into an acute concern, particularly the receptive proneness of developing countries in the face of unpredictable and constant climatic change. As such, that climate change has negative effects on the livelihoods of rural people who depend on agriculture cannot be refuted, even though agriculture plays a significant role in the economic and social well-being of the rural communities. As a matter of fact, it is the main source of livelihood in many African countries. Aniah *et al.*

(2016), confirmed that more than 60 percent of the rural population in Sub-Saharan Africa largely depends on farming for their livelihoods.

Evidently, South Africa is not exempted from the adverse effects of climate change on the livelihood of farmers. For instance, more than half of the population resides in rural areas (Alkire *et al.,* 2014). Given this, small and emerging scale maize farmers in the North West Province of South Africa contribute to the GDP and total maize production output in the country. However, maize production has dropped immensely over the years due to an increase in temperature and low rainfall which has affected the livelihood of the maize farmers in terms of profit maximization. Other effects of climate variability and change on livelihood are documented in the decline recorded in agricultural productivity and competitiveness, increased unemployment and poverty, gross reduction in food security and conflicts of resource use. Thus, this provides a sufficient reason to explore the effect of climate change on livelihood, besides exploring ways in which small and emerging maize farmers in the North West Province of South Africa can adapt.

Consequently, the findings recorded after the investigation are expected to empower emerging and small scale maize farmers in the study area to have a better comprehension of the defining features of climate change and livelihood. Additionally, stakeholders and policy makers may also utilise the recommendation from the study to assist farmers on diverse issues relating to climate change effects and practices, which will in turn improve farmers' standard of living. The policy implication of this research is to put in place some measures and practices in order to address the effects of climate change on maize farmers so as to promote adaptation, with a resultant improvement of their financial capital livelihood.

1.7 Summary

This chapter advanced the background on climate change and livelihood among small and emerging maize farmers in North West Province of South Africa. This section revealed that climate change constitutes an important environmental issue that adversely affects farmers' livelihood. It also presented a survey of the different postulations proffered by different scholars on climate change, climate change adaptation, and mitigation strategies. The motivation for the study, objectives of the study, and the problem statement were elucidated.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The livelihood of the rural households is vulnerable to weather and climate variability which results into poor rural livelihood capitals. Weather is becoming warmer and the temperature is constantly increasing, while there is a shortage in rainfall pattern. Climate change is a serious environmental peril to agricultural production as it worsens farmers' livelihood because of its direct impact on agricultural productivity (Obasi and Uwanekwu, 2015). According to Ozor *et al.* (2010), almost all segments of agriculture rely on weather and climate, whose inconsistency has made the rural farmers encounter failure in their farming business due to climate change effects. This chapter explores the concept of climate change, rural livelihood, and effects of climate change on livelihood and adaptation options.

2.2 Concept of livelihood

The livelihood concepts have become noticeable as a means of mastering the factors that influence people's lives and well-being, especially in the developing countries. Livelihood involves the assets of an individual and the activities he/she engages in for sustenance and living. Accordingly, Vincent (2001), argues that livelihood concepts represent the upshot of how and why individuals organize to effectually change the environment in order to meet their needs via technology, physical work, capability, knowledge, and socializations. FAO (2009), furthered this by expounding on the benefits accrued from the eventual change which comprises food, water, shelter, clothing, health care and education.

Equally, livelihood has been described as a means of supporting oneself. There are various definitions of livelihood put forward by several authors. An instance is Lipton's (1996) definition, which states that livelihood is a situation where there is an average of 200 days of work per year, besides obtaining a benefit sufficient enough to prevent a household from the lack of basic needs. Chambers and Conway (1992), claim that livelihood constitutes the ability and belongings (supplies, capital, claims, and access) including the activities necessary for survival. However, this definition has been widely accepted by various authors like Carswell (1997), Carney (1998),

Hussein and Nelson (1998), Scoones (1998), Drinkwater and Rusinow (1999), Ellis (2000), Swift and Hamilton (2001). As postulated by World Water Assessment Programme (WWAP, 2006), livelihood denotes the different ways in which households secure and acquire the basic requirements of life, both in good and bad years.

2.3 Rural livelihood

Rural livelihood explains the well-being of the rural communities. It captures the vocational activities required by the rural people to sustain a living. Some rural livelihood activities include: agriculture (cultivation, raising farm animals), hunting and gathering, paid labour, trading and hawking, including artisan work. As a concept, Food and Agriculture posits that rural livelihood signifies the competence, potential and practical ability, assets like skill and resource or possession, and the economic activities that rural residents require for existence (FAO, 2013). As put forward by DFID (2000), a livelihood is said to be sustainable, that is, supportable and feasible when it can subsist and recover from pressures and sudden or unpredicted shocks, sustain its abilities and assets, and simultaneously not eroding the natural supply source.

In the rural livelihood (Figure 2.1), instances of sources of income or common livelihood strategies through which rural communities survive are small-scale farming, fishing, raising livestock and non-farm activities (livelihood outcomes). According to Mphande (2016), rural livelihood is entwined; though it consists of mostly agriculture, yet a portion of the populace diversifies into non-farm activities. The reason behind the expansion into other business is to achieve a lasting and good standard of living not only for themselves, but also to attain a sustainable livelihood for their households. Sustainability leads to livelihood security which places emphasis on the opportunity to use the resources and income-earning occupation to relieve or reduce shocks and meet contingencies (Acharya, 2006).

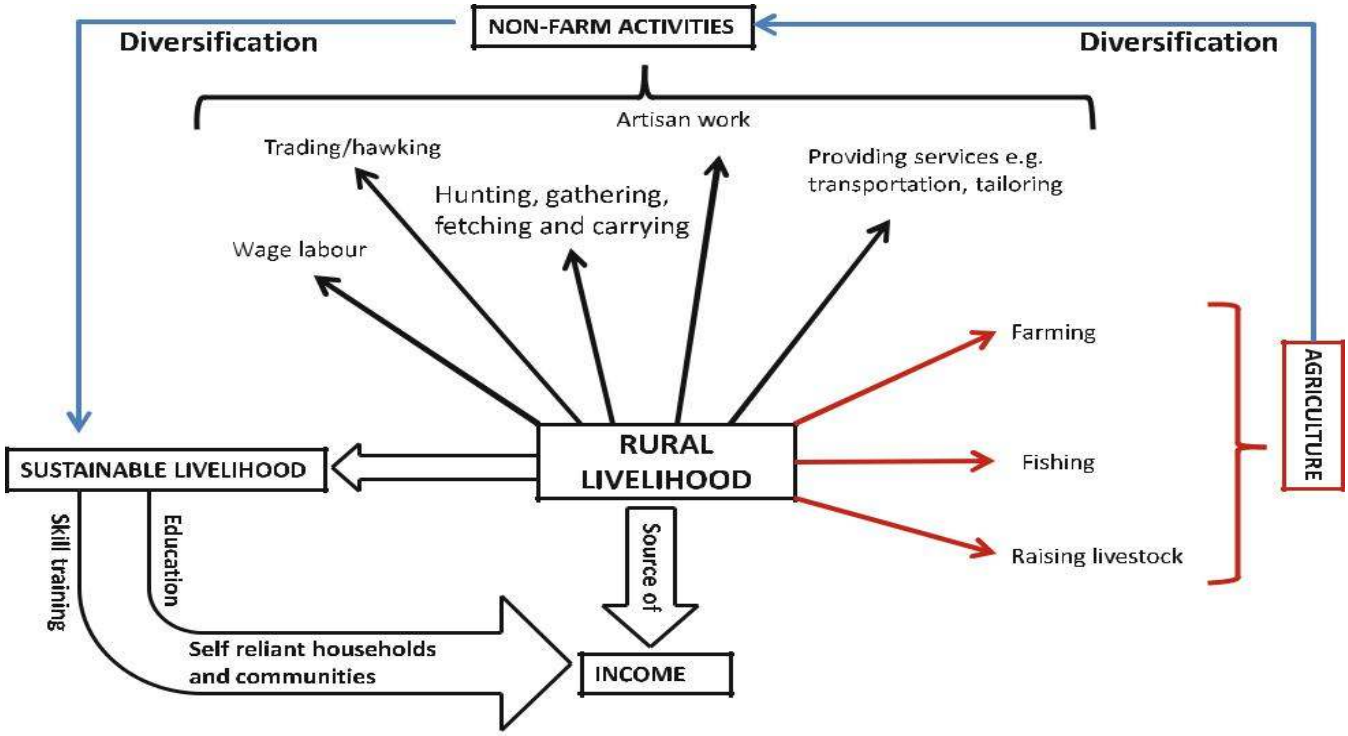

Figure 2.1: Rural livelihood framework

Source: Acharya, 2006.

Acharya (2006), asserts that rural households attain livelihood through four major ways, and they are:

Production-based livelihood

A large fraction of small scale farmers obtains livelihoods through production on small pieces of land. The availability or accesses to inputs as well as improved methods of production by this group of rural households are wholly unfavourable for their livelihood.

Labour-based livelihood

Majority of the rural households who have no land or possess a small piece of land acquire livelihood through selling their labour. Their livelihoods are dependent on the demand for labour, wage rates and prices of food; these three are vital elements for survival.

Exchange-or market-based livelihood

Rural households that produce surplus agricultural food products and non-farm goods make a living from the excess produce they sell at the market. As a result, their livelihood is directly

affected by the system of marketing that they adopt for the sale of their products, as well as influenced by the relative price of what they sell and buy.

Transfer-based entitlements

In this context, the rural households who have no income-earning assets or individuals who lack the ability to work depend on the government for social grants or other social Organisation for their livelihoods. This group of rural households obtained their livelihood through a transfer of government's allowances and programmes which are relevant to their survival.

2.4 Rural livelihood and agriculture

In developing countries, especially in Africa, rural livelihood is assertively connected to agriculture and natural resource use. For instance, Davis *et al.* (2010b), affirmed that approximately 90 percent of rural households are involved in farming activities, while in Asia and Latin America, 50 percent of the income is from farming activities (Davis *et al.,* 2010a). Mahendra (2011), also confirmed that the principal source of living for many of the Asia-Pacific countries is derived from agriculture; however, some other countries have an ample share of livelihood obtained from non-rural farming activities. Ahmed et *al.* (2015), reported that the livelihood of rural Bangladesh mainly consists of farm activities with few non-farm activities. Though, agriculture is the spine of livelihood in India, yet majority of the uneducated agrarians have not been efficacious in tilling their land for maximum economic gain (Hedge, 2002).

The rural economy mainly in most of the sub-Saharan Africa (SSA) countries, still remain agrarian. In the rural communities, small-scale farming such as crop farming and others are some of the common livelihood strategies for survival. According to Dzanku (2015), agriculture still represents the main economic livelihood activity for the majority of rural households in sub-Saharan Africa where it has been noticed that livelihood diversity is predictable or a custom. Notably, agriculture hires the largest percentage of the workforce and contributes to the prime quota of household income (Zezza *et al.,* 2009; Davis *et al.,* 2010). In Africa, 70 percent of the income in the rural households' area is from farming activities (Davis *et al.* 2010a). Rural households are usually poor and majority report food shortages several months per year (Francis, 2002; Niehof, 2004).

The inhabitants of the rural communities are peasant farmers, engaging in strenuous labour to produce crops for domestic consumption. Dzanku (2015), avowed that the Ghanaian population census (Ghana Statistical Service, 2012) revealed that about 42 percent of the labour force is actively employed in agriculture, while Kirori (2015), contended that the involvement of the rural sector in Kenya's national development is vital. A report from the republic of Kenya (2005), disclosed that agriculture absorbs more than 60 percent of the total population, hires over 70 percent of the total labour force, which provides the greater part of foreign exchange earnings, and consequently contributes more than 30 percent directly to gross domestic product (GDP). Similarly, livelihood in Ethiopia is rural, which employs almost 85 percent of the people and contributes more than 80 percent of the country's exports (U.S. Department of State, 2009).

Equivalently, the rural economy in Southern African is largely dependent on climate-sensitive sectors such as farming and natural resources for livelihood. A research carried out by UNECA-SA (2010), evidenced that in spite of swift urbanization, more than half of the people in the Southern African sub-region are still living in rural areas, mostly in villages. It was recorded that between 40 and 85 percent of the citizens of SADC member states dwell in rural areas, and they rely on agriculture for existence (UNECA-SA, 2010). Furthermore, World Bank (2007), estimated that 2.5 out of 3 billion rural inhabitants or households in the developing countries are involved in agriculture, with 1.5 billion of these in smallholder households.

In the same vein, South Africa is no exception because majority of the households in the rural areas are involved in farm based activities, and such trend could lead to the diversification of rural livelihood systems. Agriculture is deeply embedded in South Africa's culture, and many households in the rural areas make their livelihood from some form of farming activities (Silva, 2009). The South African National Department of Agriculture (2002), identified 240,000 smallholder farmers who derive their livelihood from agriculture and have one (1) million beneficiaries, in addition to providing occasional employment to another 50,000. Thus, agriculture is an imperative means of support for most of the rural people in South Africa.

The mainstay of rural household's livelihood in South Africa is agriculture because it provides either directly or indirectly, a source of livelihood for rural households. This finding is

corroborated by Nkoana (2014), who posited that agricultural production (crop cultivation and livestock) is the principal source of livelihood in the KwaZulu-Natal, South Africa, which comprises mainly poor households. The farming system in this area can be categorized as mixed crop and livestock subsistence farming. However, Anseeuw *et al.* (2001) and Perret (2003), argued that rural households create a living from various sources such as agricultural production and craft work, provide services in the form of own labour, trading, and transfers (grants and remittances), and these form the core vocation of rural people's livelihood in South Africa.

2.5 Sustainable livelihood framework

The rural livelihood is difficult and grueling as the rural dwellers are constantly deprived, and lack the basic necessities of life. On the basis of this, in order to accurately and comprehensively enunciate the issue of poverty and alleviation among the rural household, the concept of sustainable livelihood proposed by Chambers and Conway becomes necessitous. Chambers and Conway (1991) and The UK Department for International Development (DFID, 1999), expressed that sustainable livelihood entails the competence, possessions and active undertakings essential for a means of living. Congruently, a livelihood is sustainable if it can subsist and recuperate from shocks, pressure and sustain living opportunities which will in turn enhance net benefits that will nourish other livelihood (Chambers and Conway, 1991; DFID, 1999).

The Sustainable livelihood framework was adapted from a model developed by the UK's Department for International Development. It is a complete framework designed to understand poverty and to alleviate the effect on the rural livelihood. The livelihood framework is an approach to solving the difficulty of people's livelihood, specifically the livelihood of the deprived individuals (DFID, 1999). The livelihood framework is an instrument to develop our understanding of livelihood, especially the poor's livelihood (DFID, 1999). The development of sustainable livelihood framework was established to consolidate and enhance efforts from different organization to alleviate poverty. This concept seeks to comprehend numerous aspects of an individual's livelihood and interaction within the environment.

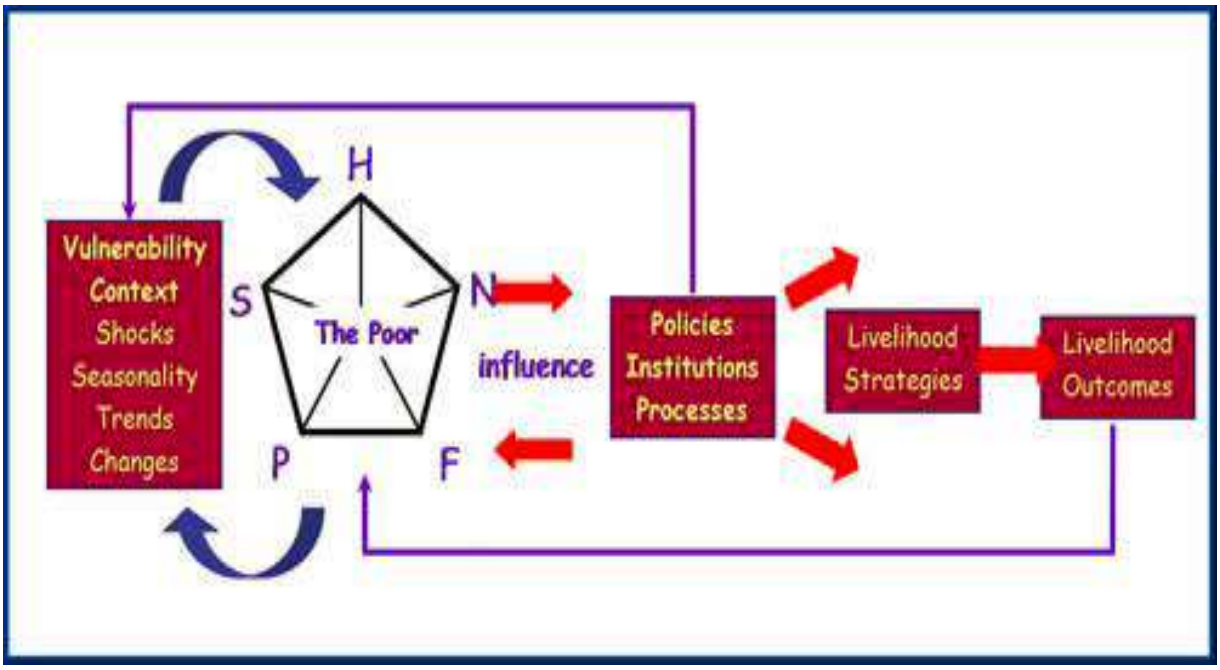

Figure 2.2: Sustainable livelihood framework

Source: Adapted from IFAD, 2007

2.6 Sustainable livelihood framework analysis

The sustainable livelihood framework analysis seeks to present primary factors, their significance, and the nature of their interactions. According to FAO (2005), five major components were identified which are vital to sustainable livelihood framework analysis. These components include vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies, and livelihood outcomes.

2.6.1 Vulnerability context

This is a key element in the sustainable livelihood framework. The vulnerability context encapsulates shocks and pressures that often affect people's livelihoods, but not always, but adversely (FAO, 2005). Vulnerability context can be unanticipated incidents liable to destabilize livelihoods and push households into an impoverishment state. However, factors that constitute to vulnerability context could be natural disaster such as in the case of earthquakes (fast acting) while slower acting could be soil erosion. Other factors responsible for susceptibility can be attributed to policies and institutions, lack of assets, economic shocks and environmental stress.

Table 2.1: Vulnerability context with illustrative examples

Vulnerability context
Weather-related shocks and natural calamities: drought, earthquakes, hurricanes, tidal waves, floods, heavy snow, early frost, extreme heat or cold waves, climate change events.
Pest and disease epidemics: insect attacks, predators, and diseases affecting crops, animals, and people.
Economic shocks: drastic changes in the national or local economy and its insertion in the world economy, affecting prices, markets, employment, and purchasing power.
Civil strife: war, armed conflict, failed states, displacement, destruction of lives and property.
Seasonal stresses: a season where food insecurity and hunger take place.
Environmental stresses: land degradation, soil erosion, bush fires, pollution and illness.
Idiosyncratic shocks: death in the family, job loss or theft of personal property.
Structural vulnerability: lack of voice or power to make claims.

Source: FAO (2005)

2.6.2 Sustainable livelihood assets

Sustainable livelihood assets consist of five capital livelihoods: human capital, physical capital, social capital, financial capital and natural capital. These assets play a significant role in survival strategies both in rural and urban livelihoods. The concept of livelihood as described by Chambers and Conway (1992) comprises: (i) people and their livelihood capabilities; (ii) livelihood assets; (iii) livelihood strategies and (iv) a living.

1) Human capital

Human capital refers to the knowledge, skills, and experience possessed by an individual or group of people, which represent them in terms of their value. Examples include water harvesting skills, climate change awareness skills, decision-making skills, soil management skills, water management skill, etc. Human capital has been defined as an accumulation of skills and knowledge through experience, education, and training of an individual (Ostrom, 1998; FAO, 2000; Padilla-Fernandez and Nuthall, 2001).

2) Physical capital

Physical capital is concerned with factors of production such as machinery and buildings. The term can also be ascribed to the physical asset that is made by human beings, and are used in the process of production. While expounding on physical capital, Ellis (2000), voiced that it helps to turn raw resources into final products and/or services. Infrastructural and structural facilities are very good examples of physical capital, including buildings, irrigation canals, road accessibility, irrigation infrastructure, storage facilities availability, etc. Additionally, Mpandeli (2016), indicated that accessibility to physical capital enhances productivity, and this eventuates in an increase in household income. Following this, in order to use physical capital, there is a need for human capital to acquire the required skills.

3) Natural capital

Natural capital is a natural asset which includes soil, air, water, climate, indigenous plants and animals, and all living things. A report submitted by International Commission on Irrigation and Drainage (ICID, 2007) opined that natural capital refers to the naturally occurring phenomenon or products, as opposed to man-made ones. In view of this, natural capital is vital in the cultivation of crops, raising of livestock and production of fiber to sustain livelihood. An example of natural capital is land, and it serves as a basis for which physical capitals stands to operate and function.

4) Financial capital

Financial capital refers to a funds needed for the execution of certain activities that are meant to sustain a living. The fund can be in the form of money that entrepreneurs and businesspersons use for the procurement of raw materials and other inputs (Boldizzoni, 2008). Essentially, availability of capital allows the growth of an investment through acquiring knowledge, skill and farm

diversification. Also, funds are needed by the rural farmers to carry out farming activities especially in a commercial farm in the purchasing of agrochemicals and fertilizers, erection of structures and the management of the farm. This is one of the main reasons most African farmers engage in subsistence farming as a result of lack of financial capital resources to venture in agribusiness.

5) Social capital

Social capital is a reference to the networks among a group of people who live and work in a certain environment, in order to function effectively. It is a signification for an association which gives a sense of belonging to a certain group of people. Network with farmers' unions, Network with farmers' association, Network with farmers' cooperative, farmer to farmer group are typical depictions of social capital. These associations and ties form a basis to access information that can be of great assistance to the farmers.

Table 2.2: Types of livelihood assets with illustrative examples

Types of livelihood assets	
Human capital:	household members, active labour, education, knowledge, and skills
Physical capital:	livestock, equipment, vehicles, houses, irrigation pumps
Natural capital:	access to land, forests, water, grazing, fishing, wild products, and biodiversity
Financial capital:	savings/debt, gold/jewelry, income, credit, insurance
Social capital:	kin networks, group membership, socio-political voice, and influence

Source: FAO (2005)

2.6.3 Transforming structures and processes

Livelihood framework refers to policies, institutions, and processes. It observes the social, political, institutional and organizational context of livelihoods. While policies have to do with enforcing law and legislation, institution is a custom or practice of a community. The functions

are to coordinate expectations by providing assurance regarding one's own actions and those of other people (Schotter, 1981; Hardin, 1982). The process describes the interactions between the structures and individuals. This framework influences the livelihood in such a way that policies must be apt to accommodate structures instigated by a proficient institution. A good organization takes steps to ameliorate the processes and structures of an individual as well as focusing on building institutions.

2.6.4 Livelihood strategies

Livelihood strategies are integration of several activities engaged by an individual household to ensure a living. It tends to focus on income sources. Basically, the ability of rural household to diversify livelihood strategies enables the pliability to pressures and shocks within the vulnerability context. Livelihood strategies seek ways and methods that can be used to improve the prospects of the poor's livelihood. Most of the farmers (rural household) have several incomes, which could be a combination of farming, off-farm and non-farm activities in different seasons to earn a living. Subsistence agriculture is declining in rural areas (Baipheti and Jacobs, 2009). Today, many rural households are engaged in non-farming activities, which are the most livelihood strategies than farming (Monde, 2003). According to Ankomah (2001), if rural households are unable to grow crops, keep livestock or purchase enough food, there may be hunger in their households.

2.6.5 Livelihood outcomes

Livelihood outcomes are what rural households pursue to accomplish strategies through their livelihood. It is a concept that varies accordingly, from place to place, time, context, and individual. According to FAO (2005), its outcome includes food security levels, increase in assets, income security, good health, family well-being and high status in the community; however, failure to achieve livelihood outcomes result into food insecurity, poverty, high susceptibility to shocks and loss of assets.

Table 2.3: Key linkages in the Sustainable Livelihood Framework

The key linkages in the Sustainable Livelihoods Framework
The vulnerability context influences household livelihood assets
Policies and institutions also influence household livelihood assets
Policies and institutions can increase or decrease individual vulnerability
Household asset ownership widens livelihood options
Asset ownership decreases vulnerability and increases ability to withstand shocks
The range of livelihood options influences livelihood strategies
Different livelihood strategies lead to different livelihood outcomes (positive and negative)
Livelihood outcomes influence the ability to preserve and accumulate household assets

Source: FAO (2005)

2.7 Maize farming and sustainable livelihood

Fundamentally, maize is consumed directly and serves as a staple food in Sub Saharan Africa (SSA). Correspondingly, in developing countries, maize provides a diet for about 200 million people (Jéan du Plessis, 2003). It is reported that maize is a preferred crop for about 900 million farmers and consumers both in low and middle income countries (The International Maize and Wheat Improvement Center (CIMMYT) and The International Institute of Tropical Agriculture (IITA), 2011). Subsequently, it is apparent that maize production has provided a means of livelihood for about over 90 percent of resource poor maize in the developing countries. However, in spite of the significance of maize for rural livelihood in SSA, its production remains low. In the same manner, Shiferaw *et al.* (2011), reported a decline in the production over the years due to climate change. Maize production in the regions is affected by change of climate and variability which adversely influence the rural livelihood of small scale farmers.

Although maize production is well known as an essential grain crop in South Africa, but it is cultivated throughout the country under different environments (Jéan du Plessis, 2003). Gilimani (2005), reported that maize is the main crop commonly grown among the small scale farmers which enhance their livelihood. Other crops include beans and vegetables (Andrew *et al.,* 2003). According to Matji (2015), maize is mainly farmed in the Highveld region, which constitutes the whole of Gauteng, almost the whole of the Free State, portions of the Northern Cape, Mpumalanga, North West and Limpopo**.** Small scale farmers and the rural households in the areas depend on maize production as livelihood strategies adopted.

The contributory role of maize production to the economy of North West Province of South Africa is very vital. This stance is authenticated by a report from NDA (2001); for it published that about 240 000 small-scale maize farmers in South Africa make their living from supplying maize to the local market. Moreover, the same report predicted that about 3 million small-scale maize farmers are located in the rural homelands, and they produce primarily to meet the dietary needs of the households, and besides they depend on maize production farming for their survival. Consequentially and significantly, these same farmers consist of more than half of the country's provinces and about 40 percent of the country's total population (NDA, 2001).

2.8 Understanding of climate change

Climate change is a change in weather condition over a certain period of time. IPCC (2001), verbalized that climate change is a statically significant difference in weather conditions that hold for a prolonged period of time, usually decades or more. Analogously, IPCC (2007), advanced that it is a change in the state of the climate that can be deciphered via the instrumentation of statistical examination. In consequence, this atmospheric variation is particularly recognizable through the changes in the mean and/or the variability of its properties, and that persevere for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (Hasan, 2015). Equivalently, UNFCCC (2009), attested that climate change is a change in the climate system that can be directly or indirectly ascribed to the activities engaged in by human beings, which subsequently eventuate in the alteration of the global atmospheric composition.

Also, a change in climate variability such as rainfall, wind and temperature are depictions of climate change. World Meteorological Organisation (WMO, 2009), vocalized that climate change is a representation of statistical description of weather of a region, with regards to its mean and variability of the parameters, for example, when the variation of temperature and precipitation span over 30 years. Appositely, Cruz *et al.* (2007), theorized that climate change pictures changes that are marked by an increase in the occurrence and high events of extreme weather. Climate change can be characterized as increase effect of global warming. Climate change is expressed as extreme temperature, uncontrolled rainfall resulting into a flood, rainfall which exhibits notable spatial and temporal variability. In the same vein, Wang *et al.* (2010), explained that climate change will generate continuing variability regarding the rise in sea level, increased temperatures resulting from movement of climatic zones and changes in precipitation patterns.

2.9 Impacts of climate change on livelihood

There is an increasing proof that climate change, particularly with respect to increasing temperature, presents a negative substantial influence on biological, physical and human systems, and it was anticipated that the impact will become more serious and severe in the future. In view of this, livelihood capital is being threatened among many global issues such as water. Climate change, however, may result into changes in precipitation patterns and frequently extremely heat waves, and this will causally produce a huge impact of climate change on livelihood. As earlier mentioned, it has been noted that nearly half of the world's population live in developing countries, totaling over 2.5 billion people (United Nation UN, 2014), and many of them depend on agriculture to make a living, which necessarily means that climate change will have an enormous but negative mark on their livelihood.

Importantly, a significant fraction of the rural household lives in areas that are challenged by arduous agro-climatic conditions such as low rainfall, poor soils, poor infrastructure (IFPRI, 2001; Acharya, 2006). IFPRI (2013) and Kang *et al.* (2009), projected a negative universal and comprehensive impact of climate change on agriculture, nevertheless, it is still possible to experience an increase in crop yield in some certain parts of the world. Thus, it is pertinent that several studies on climate impacts and adaptation strategies are gradually becoming major areas

of scientific concern especially on the impacts on livelihood and production of crops such as maize, wheat, and rice (Chande *et al.,* 2006).

It is a palpable fact that the impact of climate change distinctly contributes to social problems among farming household, and farming happens to be the major economic activities for many rural households. Mofokeng (2008), reported that the high unemployment rate in the rural areas of South Africa has occasioned escalating dependence on natural resources as major production assets to create employment and generate income. However, the number of rural households cultivating their fields has dropped probably as a result of harsh climatic changes, among other recent challenges (Perret *et al.,* 2005; Kariuki, 2003). A study conducted by Van Averbeke *et al.* (2011), stated that in Limpopo farming is only one of the several sources of livelihood for rural households, and these sources are susceptible to the negative impact of climate change.

2.9.1 Impact of climate change on social capital livelihood

Agricultural communities have suffered a hardship which has severely affected rural livelihood. Oduniyi (2014), revealed that climate change affects individuals and groups differently, for example, some group of people such as the elders, children, tribal group, low-income population are more sensitive to climate change impact compare to others. In consequence, the dire effect of climate change on social capital livelihood reflects on food insecurity, network with other farmers, forming association and cooperatives.

From the foregoing, it is therefore evident that the impact of climate change among households farming poses and engenders a remarkable threat to food security, which in turn put livelihood at risk. Davidson *et al.* (2003) findings substantiated this standpoint; for the researchers avowed that the risk of food insecurity which is prompted by the active force of climate change constitutes one of the greatest challenge for Africa, where agricultural yields and per capita food production have been progressively diminishing, and the population growth is estimated to double the demand for food, water, and forage in the next 30 years. According to International Labour Organisation (ILO, 2007), the significant role of agriculture for food security cannot be refuted, for besides functioning as a plausible channel of food production for the populace, it equally serves as a font of primary livelihood for about 36 percent of the world's total workforce.

2.9.2 Impact of climate change on financial capital livelihood

The impact of climate change on financial capital livelihood are underscored in the decrease in income, grant, credit, etc., with a causal poverty. Irrefutably, poverty continues to be a major problem in many parts of the world, and it cannot be ignored. As stated by Enete and Amusa (2010), the ratio of Africans living in penury is far greater than any other region of the world. Throughout the whole region, rural poverty still accounts for 90 percent of total poverty and about 80 percent of the poor still rely on agriculture or farm labour for their livelihood (Otive, 2006). In the meantime, the impact of climate change on livelihood could result into loss of profit, unemployment, and poverty. Poverty is a state of being poor or want. This can be shown through poverty line. Poverty line estimates a minimum level of income needed to secure the necessities of life.

As earlier noted, poverty is more pronounced in the rural areas as the majority of the rural households spend less than international poverty line per day. The increased rate of poverty among the farming household can be connected to the adverse effect of climate change. According to World Bank (2015), it was reviewed that the international poverty line is US$1.90 a day; while IFPRI (2001), reported that a ratio of about 75 percent of the total poor households live and work in the rural areas. Nearly 90 percent of the total poor live in Asia and Sub-Saharan Africa. Asia accounts for about two-thirds of the total world poor, with South Asia accounting for 43 percent. In the previous decades, FAO (2001), divulged that the number of malnourished people in Sub-Saharan Africa increased significantly, to an estimated 180 million people between 1995 and 1997. During this period, the average daily Sub-Saharan African food contained 2188 kcal/person/day compared with 2626 in developing countries as a whole.

2.9.3 Impact of climate change on natural capital livelihood

Natural resources are the free gift from nature which can be used for economic gain to support livelihood, some of which are land or soil, air, water, amongst others. There is a growing recognition that natural capital livelihood and climate change impacts are closely interconnected. For example, the impact of climate change in a form of flood affects the water quality in fish production and prevalence of pest and diseases in crop production. Climate change and variability threaten the natural resources used by the farmers in the production of food and fibers especially in Africa where resources are limited to support farming activities and production.

1) **Water quality and availability**

Temperature increase, fluctuation in precipitation patterns, rise in the sea level and excessive events can affect the water quality and its availability in many regions. IPCC (2007), projected the decrease of the available freshwater in central, southern, eastern and south-eastern Asia, especially in large river basins due to the impact of climate change which will adversely affect more than a billion people by the 2050s. On a similar note, IFAD (2009), posited that in many areas of the Asia/Pacific region, there is a struggle to put in place an active plan, in order to resist the impacts of climate change on water quality that will enable the management of water resources so as to also ensure a secure supply to the fast growing populations.

Natural water resources in Africa are being threatened continually by the impact of climate change, and this threat has culminated in increased water stress. In a study carried out by Nyong and Kandil (2009), they indicated that water is a pivotal constituent of Africa's natural asset; it is a natural gift that is elemental to economic development. Despite this, lack of water has become a major obstruction and hindrance to growth in Africa (Maponya and Mpandeli, 2012). Compatibly, IPCC (2007), verified that about 300 million people in Africa suffer from water shortages due to climate variability, increasing water demand, and poor management of available resources. Still, Schulze (2000), contended that even a slight decline in rainfall over large areas will inevitably result into a huge decrease in river water and it is envisaged that by the next decade, between 75 and 250 million people are likely to be exposed to a high considerable water stress due to climate change.

Studies have shown that water resources in southern Africa are exposed to climate change; for instance, Schulze *et al.* (2005), opined that though problems related to water are already in existence in the region, yet they are likely to exacerbate solely because of climate change. Moreover, extreme rainfall event is bound to inflate the occurrence of flood in many areas in the region; even so, the run-off impact will worsen current water stress, besides leading to a reduction in the quality and quantity of water available for domestic and industrial uses.

That South Africa is a water-stressed nation cannot be gainsaid; this fact is particularly registered because its existing water resources are perceptibly under pressure to meet a growing demand. Schulze *et al.* (2005), observed that South Africa is a manifestly dry country with a mean annual

rainfall of about 490 mm (half the world average), and out of which only a minute 9 percent is converted to river run-off. Department of Environmental Affairs (DEA, 2010), asserted that conversions in rainfall patterns as a result of climate change impacts will literally trigger more floods in the eastern part of the nation, in addition to causing more droughts in the western parts.

2) Soil

Climate change can have an enormous effect impact on soils as a natural resource and the functions that soil performs. It is a patent fact that there is a direct connection between soil and climate change because climate alteration will necessarily affect the nature and distribution of ecosystems in the soil. The soil holds water, contains nutrients, in addition to serving as a growing medium for plants, and equally a habitation for animals. Likewise, as climate changes, the soil's ability to support current ecosystems effect changes in the communities of plants that are grown in different parts of the world. Consequently, it is noted that extreme increase in temperature ultimately affects the lives of microorganisms which facilitate the decomposition of organic matter in the soil. According to European Environment Agency (EEA, 2015), there are already clear indications that soil moisture content is being affected by rising temperatures and changes in precipitation patterns.

2.9.4 Impact of climate change on human capital livelihood

Human capital is a pool of quality, which includes experience, skills, training, wisdom, talents an individual possessed. As postulated by Sheraly (2015), human capital denotes the accumulation of personal attributes, knowledge such as creativity embodied in an individual so as to generate economic value. Examples of human capital livelihood include employment, education, personal skill development and training which can enhance one's life in his/her area of endeavour.

1) Education

Climate change plays a significant role in human capital livelihood, particularly concerning most rural farmers. Reports from Save the Children (2008) and UNICEF (2008), stated that the influence of climate change will be mostly perceived through its interference with educational provision. An instance is represented in the case of Middle East and North Africa region where the period of excessive heat and flood prevents students from attending school classes; while another is a situation where flood make the road inaccessible for students to attend schools in certain places.

Likewise, the floods of June 2009 in Yemen are typical examples. Disruption and interruption in electricity are manifest potential impacts that force school's management to suspend activities.

2) Employment

Climate change has a great and undeniable influence on employment is a provable fact. According to ILO (2008c), more than 1 billion people are hired in the agriculture sector, which regarded as the second greatest source of employment worldwide after services. Asia records over 70 percent of the world total employment as regards farming, while sub-Saharan Africa is noted for almost 20 percent. China and India together represented almost 60 percent of the world's total agricultural labour force. As previously mentioned, climate change such as excessive or escalatory occurrence of droughts and floods, variability in rainfall patterns and extreme weather events exerts influence on the agricultural sector and livelihood of the people in the industries.

The agriculture in the rural area is characterized by low payment rate, poor working conditions and rising levels of poverty. The challenges that tailgate climate change will compound the enormous problems already experienced by the affected workers. Consequentially, the millions of workforce in the agricultural sector will have to effectuate a change in crop production, or yet still seek for new employment somewhere else, which may be feasible through relocation to the urban area just like in the case of South East Asia. ILO (2008c), detailed that Sub-Saharan Africa and many poor countries are at the peril of severe poverty due to the aftermath of climate. For instance, the production of cereals is mostly responsive to temperature changes and precipitation. In the same train of thought, increased sea levels may also lead to salinization of fresh water and affect water quality in an irrigation system.

2.9.5 Impact of climate change on physical capital livelihood

Infrastructural and structural resources are the physical components of interrelated systems; besides functioning as essential support, they also enhance farming activities so as to facilitate and generate maximum profit. However, notwithstanding their supplementary functions, they are destroyed by the impact of climate change events such as the flood. Transport, road accessibility, electricity availability, storage facilities availability, dam and reservoir, trellising system, fencing, accommodation and pack house, irrigation infrastructure, production infrastructure, and telephone infrastructure can be damaged by climate change. On the word of EPA (2016), climate change is

predicted to increase the occurrence and aggravate the event of an extreme weather. The United States Global Change Research Programme (USGCRP, 2014) and National Research Council (NRC, 2008), reported that events such as heat wave is expected to be more severe, rise in sea level could increase storms in coastal areas, and precipitation will likely be more intense.

2.10 Impact of climate change on agricultural production

Agriculture is highly exposed to climate change, as farming activities directly depend on climatic conditions. It follows that global climate change impact on agricultural production should be considered important (Rosenzweig and Parry, 1994). Numerous global problematic challenges currently experienced in the world today stemmed from global scientific collaborations that rely mainly on the ecosystem (Sjoberg, 2002). The upshots gave rise to the excessive and formidable environmental problem cited by Udenyi (2010). According to Hughton (2002), the earth's average surface temperature has increased by 1^0F just over the last century and consequently, climate aggravates a serious negative impact on crop yield, which has occasioned a reduction in the production of food.

The impact of climate change is very likely to affect food production at the global, regional, and local level. In every society, agriculture and food are issues that are very sensitive to climate change variability. Naturally, climate change will have overarching impacts on crop, livestock and fisheries production, and will increase the prevalence of crop pests (Campbell *et al.,* 2016). For instance, Lobell *et al.* (2011), noted the impact of climate change on crop yield in their research. Climate impact studies on crops are predominate, but impacts on fisheries and livestock production are equally preponderant (Creighton *et al.,* 2015; Herrero *et al.,* 2015). EPA (2004), projected that decrease in water flows and increases in sea level may deleteriously affect water quality and fish species in many regions.

2.10.1 Impact of climate change on maize production on international view

The impact of climate change, particularly to drought could adversely affect maize production. International Fund for Agricultural Development (IFAD, 2009), reported that, in Asia, recurrent and extreme events will be experienced such as droughts and floods which are anticipated to make maize production even more problematic. It was predicted that a change in climate will put about

49 million people at risk of hunger by 2020. Given this, it is obvious that any modification assumed by climate will effectually affect different crops and areas contrarily, but it is generally anticipated that agricultural yield will decline (Lobell and Field, 2007). According to Xiang Li *et al.* (2014), it was reported that China is the world's second largest producer (20 percent), second largest consumer (20 percent), and fifth largest importer (5 percent) of maize, yet the nation is adversely affected by the impact of climate variability.

Global agricultural production is challenged by climate change. According to Xiang Li and Nobuhiro Suzuki (2013), United States is the largest producer of maize in the world, and as such accounts for over one-third of the world market share in terms of exports. However, the future of maize production even in the region is threatened by the impact of climate change, which has consequently given rise to a concern for the global maize economy and future food security. Correspondingly, Xu *et al.* (2016), forecast a future decrease in maize yields, with variability in maize yield being strongly driven by climate variability.

2.10.2 Implication of climate change on maize production (continental view)

A continuous widespread of damage of farms and properties such as in the case of Hurricane Dineo in Mozambique, a protracted drought in Ethiopia established the extent of the threat of climate change to the farming household. The increasingly unforeseeable and inconsistent nature of the weather system on the continent has placed more problems on maize production and rural livelihoods. The Intergovernmental Panel on Climate Change (IPCC, 2007), revealed a comprehensive appraisal on the likely outcomes of climate change on agriculture in the African region. The report depicted that Africa will be the most susceptible to climate change due to numerous stresses such as poor infrastructure, poverty, governance, amongst others. FAO (2009), indicated that climate change is unfolding as a central challenge to the advancement of agriculture in Africa.

Considering the increasing pace and possibility of climate variability in Africa, maize production is bound to decrease. In a study carried out by Jones and Thornton (2003), they maintained that maize yield in Africa will likely reduce by 10-20 percent by 2050. The reduction may even degenerate to 50 percent due to climate change. Similarly, FAO (2009), pointed out that it is feasible for agricultural sector to encounter a persistent period of droughts and/or flood.

Harmoniously, evidence from the IPCC (2007), implied that areas in the sub-Sahara are likely to emerge as the most vulnerable to climate change by 2100, coupled with the plausibility of agricultural losses of between 2 and 7 percent of affected countries' GDP (Sango, 2014). Additionally, Western and Central Africa are expected to experience losses ranging from 2 to 4 percent and Northern and Southern Africa are expected to have losses of 0.4 to 1.3 percent (Mendelsohn *et al.,* 2000).

Following the preceding discussions, it is clear that the overall impact of climate change will cause a decrease in maize production under future climate scenarios. Prior researches assuredly predicted that regions of sub-Saharan Africa where maize is cultivated will experience escalatory rise in temperatures and occurrence of droughts (IPCC, 2007). For instance, Jones and Thornton (2003), used a CERES- Maize model to simulate the changes in crop yield associated with the different climate change scenarios. The study estimated a 3–19 percent reduction in maize yield by 2055 compared to 2000 in two agro-ecological zones (Ethiopia and Mozambique). As enunciated by Adejuwon (2006), it was reported that a research study carried out in Nigeria applied the Erosion Productivity Impact Calculator (EPIC) crop model to give projections of crop yield during the 21st century. The study modeled worst case climate change scenarios for maize production alongside with some other crops.

In recent years, maize yield across the Africa region has dropped. In spite of numerous projection and discussion on the impact on maize yield, there is a common concern that climate change will negatively affect maize yield in East Africa. Several studies indicated that East Africa could possibly lose about 40 percent of its maize production by the end of the 21st century (Adhikari *et al.,* 2015). Chi-Chung *et al.* (2004), reported a severe impact of climate change on maize production in semi-humid and semi-arid areas of Kenya. Obasi and Uwanekwu (2015), recorded the same result that climate change significantly affected the productivity of maize crop in Nigeria. As put forward by Barimah *et al.* (2014), it is most likely for Ghana as a country in future to experience a problem meeting the demand of maize consumption, even under the projection of climate scenarios.

2.10.3 Implication of climate change on maize production on regional view

The impact of climate change on maize production is becoming more elongated in the dry lands of Southern Africa. The occurrence of drought is anticipated to escalate on account of higher temperatures and reduced rainfall. IPCC (2001), confirmed there is a prevalent tendency for increase in temperature in different parts of the sub-region, in association with climate variability and extreme weather events. In a reviewed paper by Economic Commission for Africa Sub-regional Office for Southern Africa (ECA-SA, 2012), it was stated that the production of maize in the year 2006 fell short by 2.18 million metric tonnes due to droughts in Namibia, Mozambique, Swaziland, Zimbabwe and South Africa. Nonetheless, this situation of uncertainties and risks to food production is expected to aggravate in future.

There has been a major instability in maize yield and production trends in the Southern Africa. According to Oseni and Masarirambi (2011), the yield of maize has been falling with about 70 percent for the past period of five years. In Swaziland, maize production has been drastically reduced due to irregularity in rainfall patterns, while the adaptation method of land reduction used in the area also contributed to the reduction of maize yield in the county. FAO (2006), recounted that Swaziland has been affected below average and cereal production including (maize) is declining as a result of intermittent rainfall patterns, which are aggravating the impact of the increasing unemployment and the degree of poverty status. Msowoya *et al.* (2016), argued that maize becomes less affordable with the continued decline in yield due to the impact of climate change and variability in Malawi, however, the country could face greater food shortages and even famine.

2.10.4 Implication of climate change on maize production on national view

In South Africa, maize is largely grown in the highveld region, characterized as a summer rainfall area. The majority of the area receives precipitation between the months of October and March. The monthly average temperatures range from 28°C to 30°C in the western part of the country and 25°C to 30°C in the eastern part annually (Walker and Schulze, 2008). South African Grain Information Service (SAGIS, 2017), reported that maize is consumed directly and serves as staple food for about 200 million people in developing countries including South Africa.

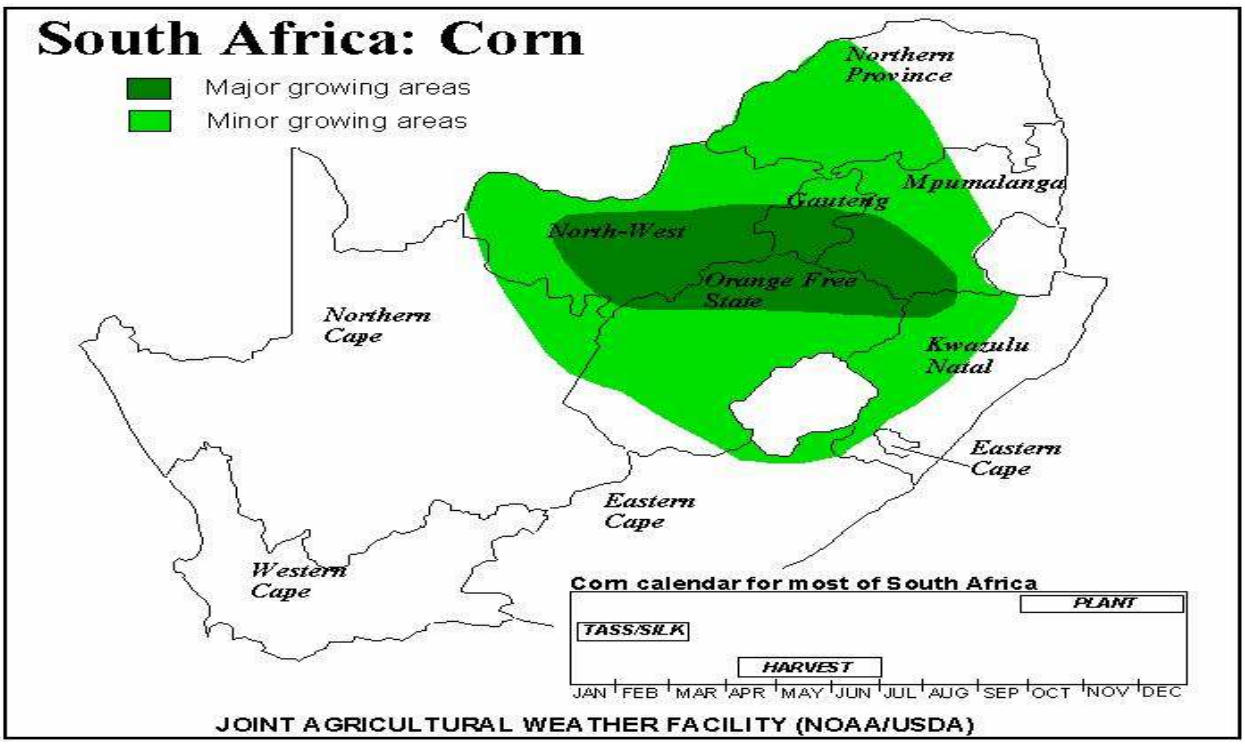

Figure 2.3: South Africa's main maize producing areas

Source: The United States Department of Agriculture (*USDA,* 1999).

Climate change affects maize production in South Africa. According to Grain South Africa (GSA, 2010), the industry is one of the largest food suppliers, producing between 25 percent and 33 percent of the country total gross agricultural production. However, the current situation as a result of climate change has led to a drastic decrease in the production of maize. It is predicted that climate which is becoming hotter and drier will generate into a remarkable decrease in the production of maize by approximately 10-20 percent over the next 50 years (BFAP, 2007). Closely related, Vogel *et al.* (2010), estimated temperature increase, which will cause 28 percent restriction in some area suitable for crop production as early as 2020.

Following the current trends of rainfall pattern, maize production would be adversely affected by the impact of climate change. Walker and Schulze (2006), indicated that the yield of maize in South Africa has been simulated to be reactive to both climate and carbon dioxide (CO_2) fertilization, with doubled CO_2 thereby offsetting much of the reduced profitability associated with a 2°C temperature rise, especially in core areas of maize production. The current inconsistence of

patterns in weather in South Africa could consequently have a substantial negative impact on the maize economy (Mqadi, 2005). According to Blignau *et al.* (2009), the total production of horticulture and field crop in all the provinces of South Africa, which contribute about 10 percent or more to the net agricultural revenue, will be likely affected by the decline in rainfall pattern, particularly in a rain-fed agriculture.

Over the last few years, there has been a major shift in area and production of maize in South Africa. The areas where maize is planted have declined significantly. Du Plessis (2003), penned that about 3.1 million ha of land in South Africa, produced nearly 8 million tons of maize grain yearly. According to NDA (2001), the maize yield in the year 2000 contributed over 15 percent of the gross value of all agricultural products, while accounting for about 40 percent of the entire cultivated area in the country. Local consumption of maize is about 7.5 metric tons per year; however, the country always produces excesses that are exported, primarily to neighbouring countries in the SADC region (NDA, 2001).

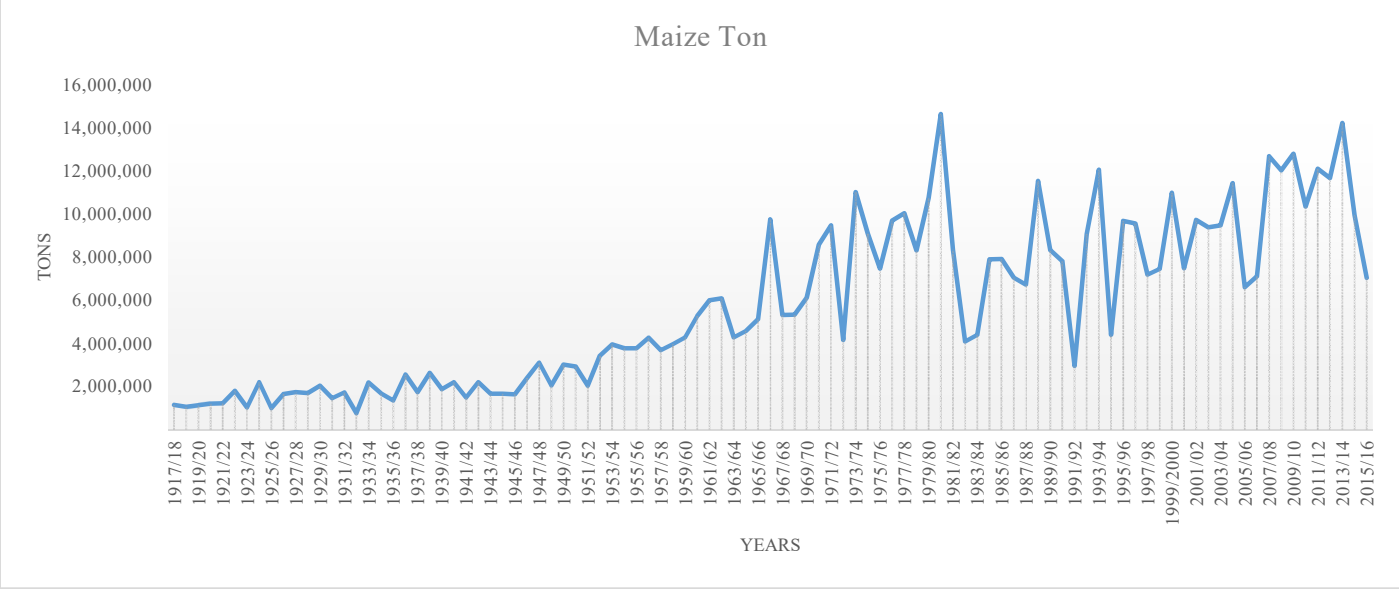

Figure 2.4: Production: Commercial Agric. - Maize

Source: ARC (2016), compiled by the author

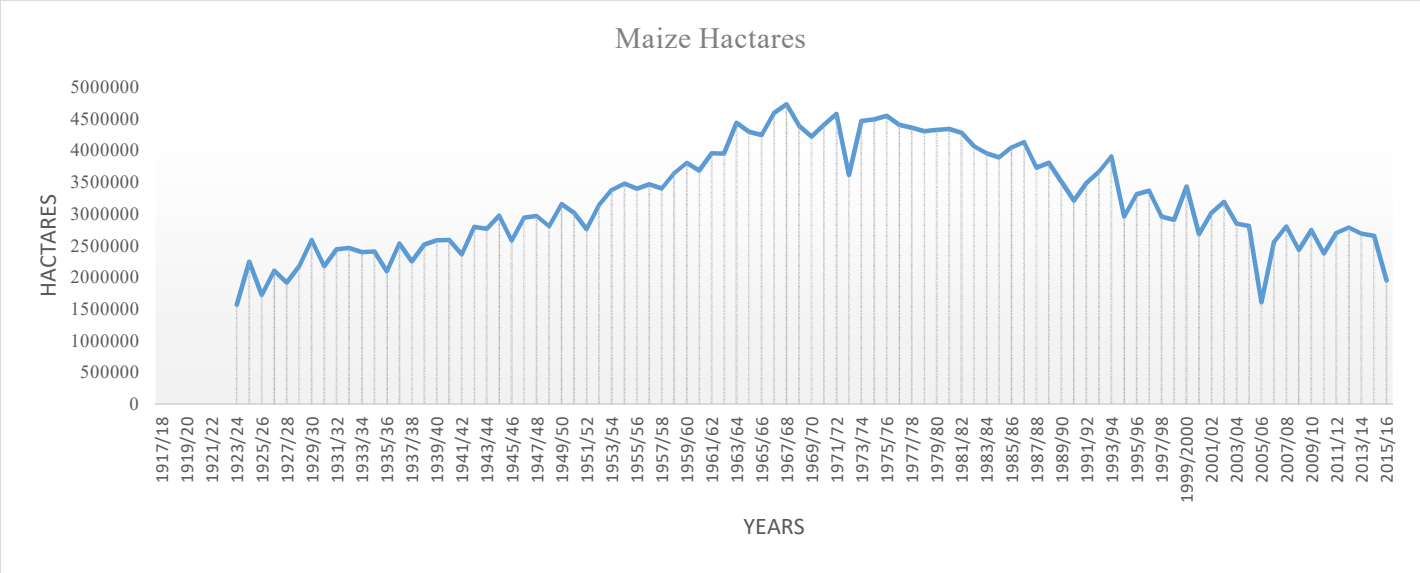

Figure 2.5: Area: Commercial Agric. - Maize

Source: ARC (2016), compiled by the author

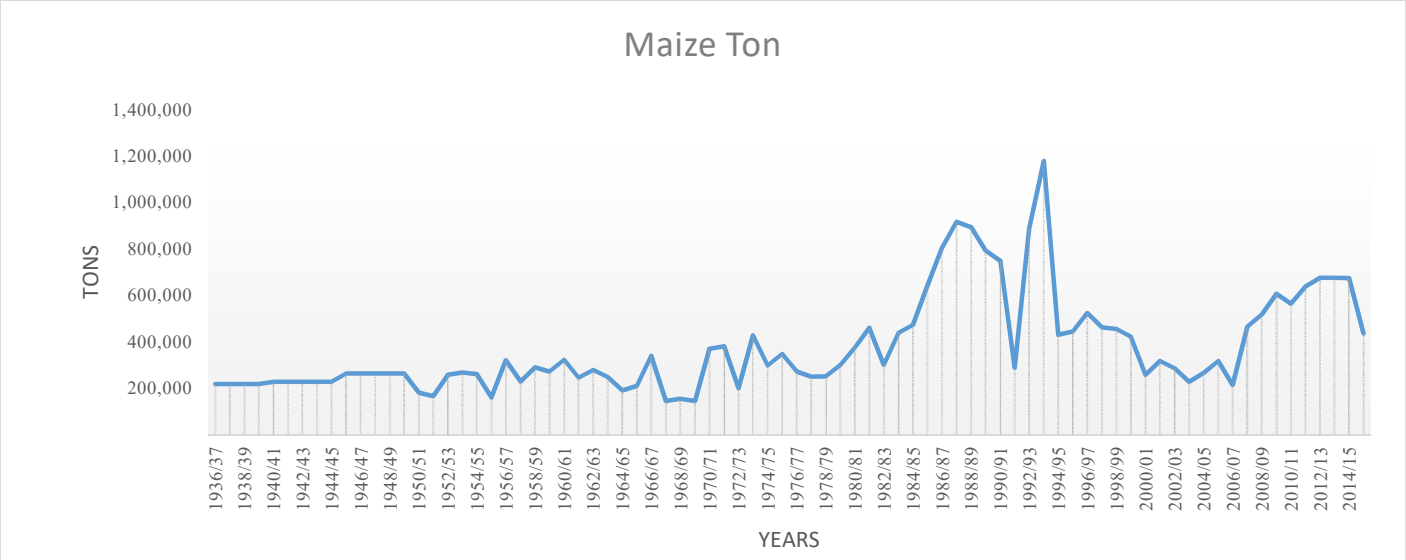

Figure 2.6: Production: Small and Emerging Agric. - Maize

Source: ARC (2016), compiled by the author

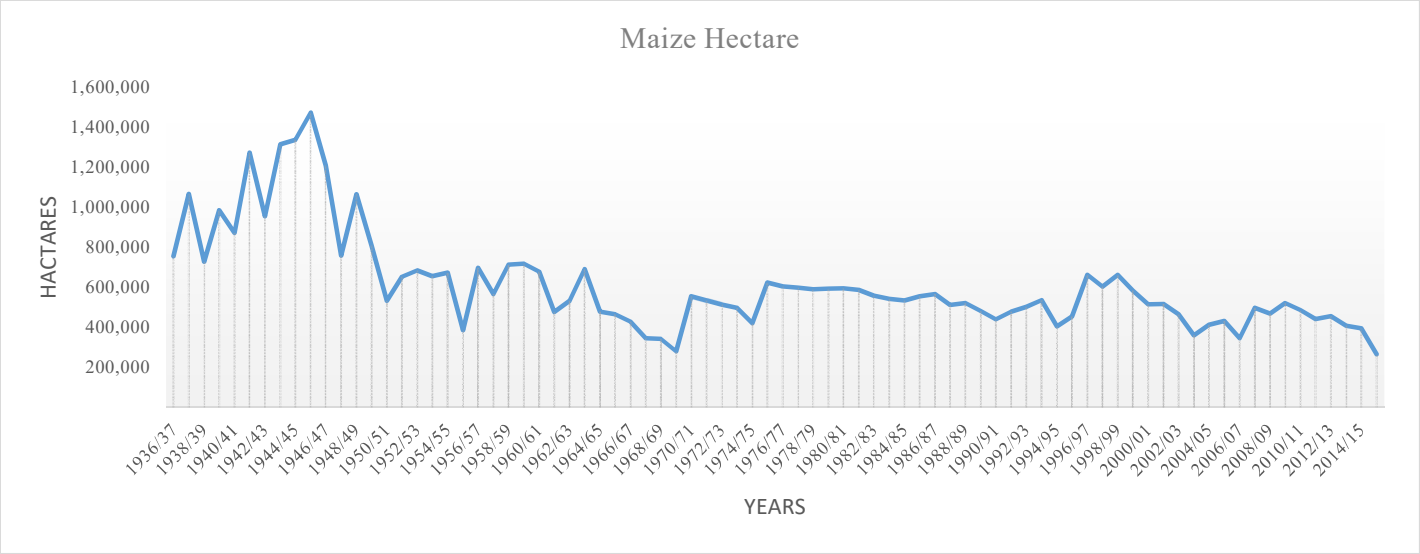

Figure 2.7: Area: Small and Emerging Agric. - Maize

Source: ARC (2016), compiled by the author

The Figures 2.4 to 2.7 show maize production variations in South Africa due to climate change. Climate change in the province has a negative impact over the years with a drastic reduction in production yield and area of farming. The decrease in the area of farming was a result of farmers changing the size of maize farming as adaptation strategies so as to cope with the impact of climate change.

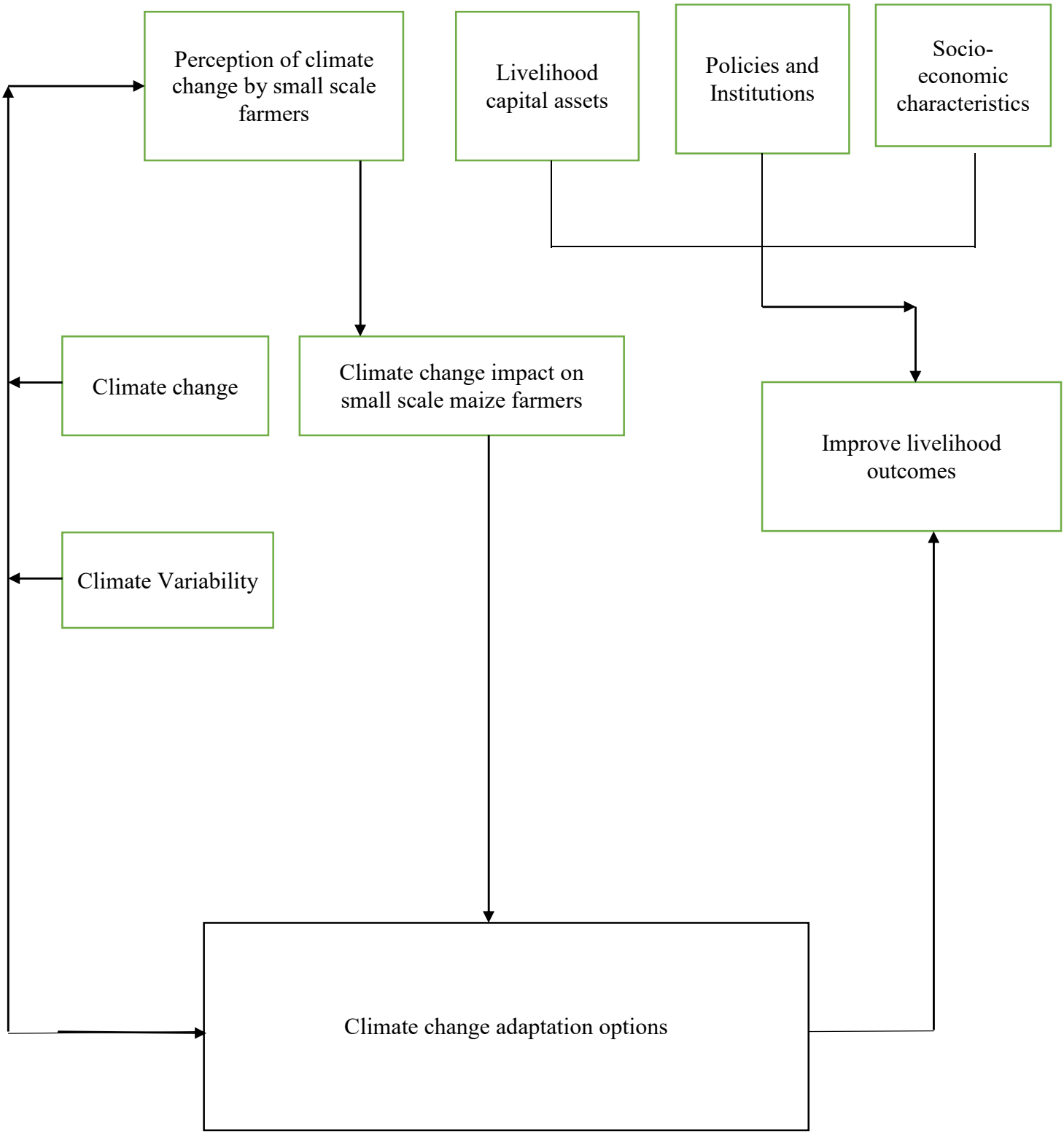

Figure 2.8: Conceptual Framework of the study.

Source: Oduniyi (2017).

In the conceptual framework explained in Figure 2.8 farmers perceive climate change and variability which result into adaptation options. Adaptation options help to reduce and enable the farmers to cope with the impact of climate change and increase livelihood among the small-scale maize farmers. However, livelihood capitals, socio-economic characteristics, policies and institutions, climate change adaption measures contribute to better livelihood outcomes.

2.11 Climate change adaptation

Adaptation to climate change can be said to be a change or modification in the agricultural farming system to minimize the negative impacts of climate change and concurrently boost or improve food production irrespective of climate variability. Smit and Wandel (2006), explicated that adaptation concept is relatively new, in addition to originating from natural science, while IPCC (2001), equally expounded that adaptation is concerned with how to manage the impact of climate change. Subsequently, adaptation to climate change can be said to be an adjustment regarding natural and human systems in response to their effects of climate change (IPCC, 2001; Deressa *et al.,* 2008).

Following this, adaptation is the prime action of sorting out or effectual handling of the impacts of climate change. It involves pragmatic approach to cope with climate impacts risk, protect people and build up resilience among rural farming household and in the region. Phuong (2011), defined adaptation as the practice of adjusting to climatic condition. Smit *et al.* (1996), indicated that adaptation to climate change will certainly demand the alterations of some practices so as to step down the marked vulnerability of climate change and simultaneously improve the sustainability of economic and social activities. African Ministerial Conference on Climate-Smart Agriculture held in Johannesburg (2011), emphasized that a call for adaptation is needed at this particular time of climate change, in which feeding Africa and the world at large pose a major challenge. It was proposed that by 2050, global food production must increase by 70 percent in order to feed over nine billion people around the world.

2.11.1 Climate change adaptation measures in maize farming

Climate change impact and adaptation strategies are the major distress areas to the body of science and as such, it is paramount that farmers should possess the ability to perceive the incongruity

associated with climate change, for it is a requisite for the adoption of adaptation (Moyo *et al.,* 2012; Kihupi *et al*., 2015). Similar to Adger *et al.* (2005), postulations in a bid to combat to climate change through the implementation of adaptation, necessity is laid upon the farmers to first perceive a change in climatic condition after which there is a need to identify and apply potential useful adaptations. According to Kihupi *et al.* (2015), adaptation strategies of smallholder farmers largely depend on their level of perception knowledge on climate change. However, several studies have been conducted around the globe on how smallholder farmers adapt to climate variations and the significance of adapting agriculture to climate change in the continent (Deressa *et al.,* 2009; Mertz *et al.,* 2009; Hisali *et al.,* 2011; Kemausuor *et al.,* 2011; Below *et al.,* 2012).

There are various adaptation practices implemented in the face of climate change impacts. Osbahr *et al.* (2010), revealed that crop varieties and livelihood diversification are some of the major adaptation measures adopted by farmers throughout the continent. In India there are some noticeable changes in the agricultural practices (maize farming) where adaptation strategies include ground water for irrigation, the use of polyvinyl chloride pipes to transport water on farms, more use of early matured cultivars, more use of crop varieties that are of high yield, change in planting date and harvesting, crop diversification, mix-cropping and agroforestry. Improving irrigation facilities and introducing cultivars were identified by Wang *et al*. (2001), in a research conducted on maize farming adaptation measures in China. However, adaptation options are subjective to different environmental factors (Gbetibouo *et al.,* 2010; Hisali *et al.,* 2011; Below *et al.,* 2012).

Many of the countries in sub-Saharan Africa are most exposed to the impact of climate change, due to high reliance on agricultural production and little adaptive capacity. Boko *et al.* (2007), expatiated on the effects of climate change in sub-Saharan Africa, which are practically seen where the length of the growing season is reduced which inevitably forces agricultural business out of production. According to Deressa *et al.* (2011), adaptation measures used in the Eastern coast of Africa in maize farming were the utilization of different maize cultivars, irrigation and change of planting dates. Equally, Mary and Majule (2009), reported that in Tanzania the rural farmers adapt by simply changing the date of planting. Furthermore, rural household in Tanzania engage in the burying of crop residues to improve soil fertility and burning the residues to control pest

infestation. Additionally, in SSA diversification of livelihood strategies to non-farm activities were practiced.

In Southern Africa, there are some adaptation measures that are used to improve the yield of maize. According to Zvigadza *et al.* (2010), it was reported that in Zimbabwe, traditional coping strategies were identified with the aim of adapting to the aftereffects of climate change. The use of water recycling on the farm, indigenous method of water conservation, practising spiritual exercise requesting for rain were all used. According to Ndhleve *et al.* (2017), in South Africa, supplementary irrigation and change of planting date were identified for adaptation strategy. Farmers engage in adaptation by re-planning or shifting of the planting date to earlier or late to adapt, the use of forecasting and weather report were all measures used.

2.12 Summary

This chapter expounded on the concept of livelihood which involves rural livelihood, sustainable rural livelihood, sustainable livelihood framework, sustainable livelihood assets, and livelihood strategies. The concept of climate change and its impact on livelihoods was explained which is seen on the human livelihood capital, social livelihood capital, physical livelihood capital, financial livelihood capital and natural livelihood capital. The impact of climate change on maize production was discussed at length. The various adaptation measures and mitigation strategies were also discussed.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodological approaches followed in this study. The chapter describes the study area, size, and location on the map, the population and the agro-ecological zones with regard to maize production in the study area. It also elucidates the sampling techniques, data collection, data analysis and the econometric modeling to address the objectives of the study. Summary of the chapter is also included.

3.2 Study area

The study was carried out in Ngaka Modiri Molema District Municipality of the North West Province. The province is located in the north of South Africa sharing a border with the republic of Botswana and the Kalahari Desert to the west, where Gauteng province is found on the east and the Free State to the south. North West province is the fourth smallest province in the country. It was established in 1994, acquiring 8.7 percent of land area (106 512 km^2) in South Africa. Its landscape is demarcated by Magaliesberg Mountain in the northeast, which covers about 130 kilometers from Pretoria to Rustenburg, while the Vaal River is located on the South border of the Province. Mahikeng (previously Mafeking) is the capital and most economic activities in the province (over 80 percent) take place around Potchefstroom, Klerksdorp and Rustenburg. Mining is the major contributor to the economy of the Province followed by farming activities in which maize is predominantly planted.

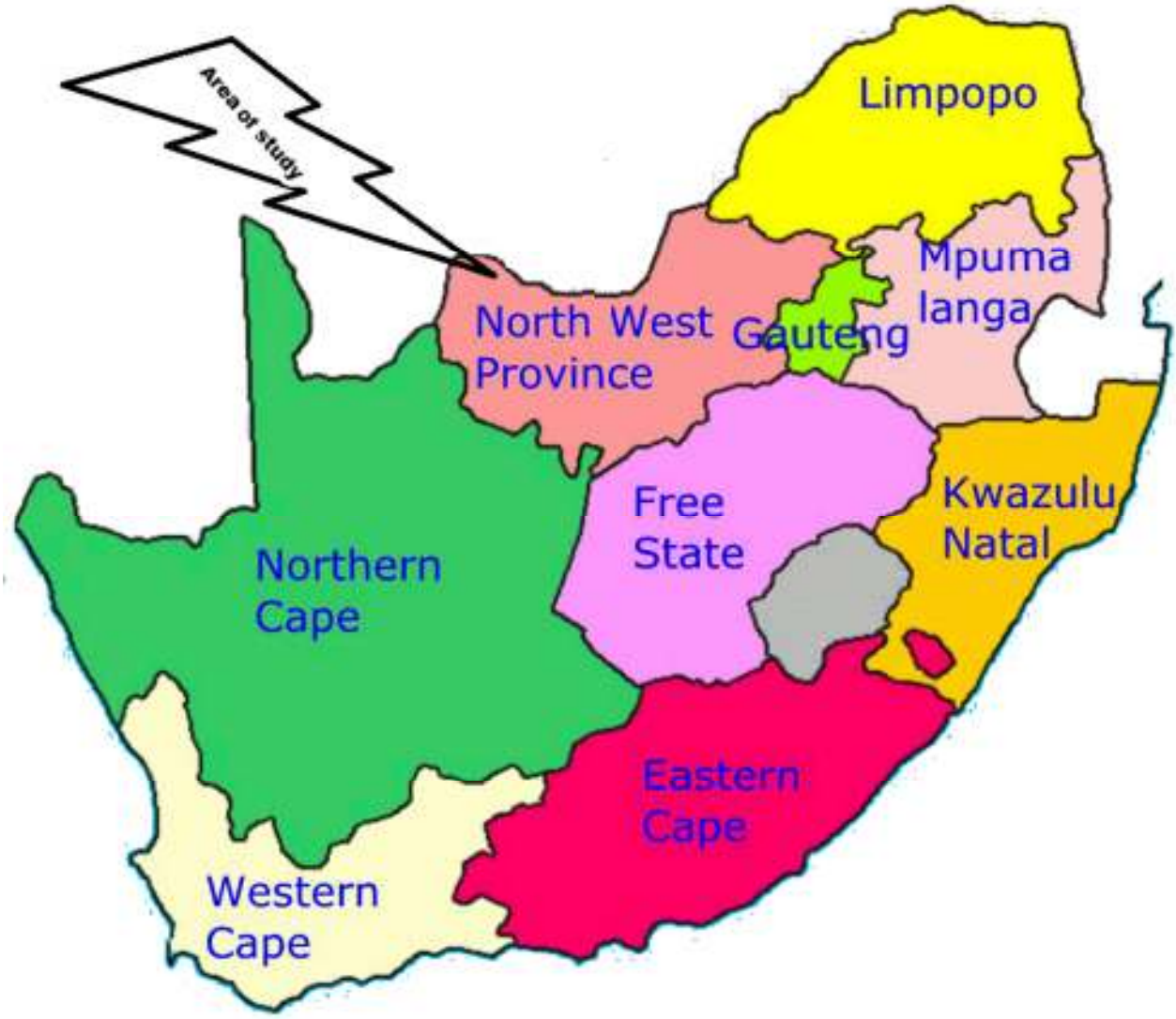

Figure 3.1: Study area on the map of South Africa

Source: Municipality and Demarcation Board of South Africa (2009)

Figure 3.2: Districts and local municipalities in North West Province

Source: Municipal Demarcation Board (2010)

North West Province consists of four district municipalities. They are Ngaka Modiri Molema District Municipality, Bojanala Platinum District Municipality, Dr. Ruth Segomotsi Mompati District Municipality and Dr. Kenneth Kaunda District Municipality. The districts are divided into 18 local municipalities. However, the study was carried out in Ngaka Modiri Molema District Municipality. The district is the capital of the Province which is situated at the centre of the province and shares a border with Botswana. The district consists of Mahikeng, Ditsobotla, Ramotshere Moiloa, Tswaing, and Ratlou. The area of the district is 28,206 km^2 with a population of 842,699 (Stats SA, 2017). The main economy is agriculture.

Figure 3.3: Map of Ngaka Modiri Molema District Municipality

Source: Municipal Demarcation Board (2010).

3.3 Population, sampling procedure and sample size

Data were collected from Ngaka Modiri Molema district municipality in North West Province, which consists of 5 local municipalities as shown in Figure 3.3. The list of small and emerging maize farmers in the district comprising about 575 farmers was obtained from Department of Agriculture, Forestry and Fisheries (DAFF) and also from Grain SA. Raosoft sample size

calculator was used to determine the sample size from the population of the small and emerging maize farmers in the study area. The sample size calculator took into account the confidence level, the response distribution and the margin of error as indicated below:

$$x = Z\left(c/100\right)^2 r\,(100-r) \quad \text{(3.1)}$$

$$n = Nx/(N-1)E^2 + x) \quad \text{(3.2)}$$

$$E = \text{Sqrt}\left[(N-n)x/n(N-1)\right] \quad \text{(3.3)}$$

A total number of 346 questionnaires were administered to the farmers in the district using stratified random sampling technique. This technique was employed to group the population of the farmers from the 5 local municipalities in the district into strata. Thereafter, random sampling was used to select from each stratum. A specific number of the sample size was selected from each stratum as shown in Table 3.1.

Table 3.1. Data collection according to the selected local municipalities.

Stratum (Local Municipalities in the District)	Population of small scale maize farmers	Selected sample size
Tswaing	200	132
Ditsobotla	150	109
Mahikeng	100	80
Ratlou	15	15
Ramotshere Moiloa	10	10

Source: Author's computation, 2017

3.4 Method of data collection

This research used a quantitative design method. Approval to collect data was conceded by each local municipality's office in the district. The data used in the research were primary and secondary data. Primary data were used to collect opinions from the farmers through the use of

questionnaires, while the secondary data supplied additional information and other existing literature and evidence to equipoise the primary data collected, through use of published books and journals. The questionnaires were explained to the local extension officers before the survey because they understood the farmers better and could translate the questions into the local language. Face to face interviews and focus group discussions were conducted in each local municipality where each session lasted for about 45 minutes.

3.5 Research instrument

An appropriately-designed questionnaire written in English was used as a research instrument to collect data. The questionnaires were filled in anonymously as no personal questions regarding names, addresses and identity numbers were asked. Section A comprised of rational questions which accommodated and focused on issues involving: (a) demographic and household characteristics, (b) land characteristics, (c) climate change related issues, (d) climate change awareness, (e) climate change and livelihood, (f) adaptation measures options were asked from respondents.

3.6 Validity and reliability

In the study, prior to empirical research data collection, the questionnaires were tested and validated to the respondents. During the pre-testing period, a sample of 20 households was randomly selected and interviewed in the two district municipalities. Questions that were found to overlap during the questionnaire's pre-testing were deleted and others that were ambiguous were modified to ensure clarity. The questionnaire's pre-testing also helped to improve the translation of the questionnaire into Setswana, the local language for the respondent to understand better.

A half technique was used to determine the reliability of the instrument. A reliability coefficient of $r = 0.80$ was obtained which was considered to be good for the instrument used. The questionnaires were reliable, consistent and accurate in response to the objectives of the study to minimize error. It measured the attributes it was designed to measure. The questionnaires showed the likelihood of obtaining the same results when the researcher measures the same variable more than once, or when more than one person measures the same variable.

3.7 Analytical techniques and methods

The data collected were captured and analyzed using the Statistical Package for Social Sciences (SPSS, version 23, 2015) software. SPSS software can be used to assist in calculating a variety of statistical analysis which has dynamic data processing ability. This was used in this study to achieve descriptive statistics, binary logistic regression model, and other data analytical interpretations (See Table 4.1, 4.2, 4.3, 4.4, 4.5 and 5.2). STATA software was used to achieve the test of multicollinearity of variables (See Table 5.1, 6.2 and 7.1). EVIEWS software was employed to analyse Tobit regression model and Two-stage least square regression model (See Table 6.3 and 7.2) while the XLSTAT software was used to bring clarity at some point during the study to perform Principal Component Analysis (PCA) and determine the Eigen values (See Table 6.1). XLSTAT is a suite of statistical add-ins for Microsoft Excel which can be used for statistical analysis. Also, it enhances the analytical capabilities of Microsoft Excel. There are different analytical tools used according to the objectives of the study. These consist of descriptive and inferential statistics.

3.7.1 Descriptive statistics

Descriptive analysis was used to analyse the socio-economic characteristics of the respondents and to identify the adaptation options and mitigation strategies used in the study area which are objectives 1 and 2 of the study respectively. Graphical representations, percentages, frequency distributions, and statistical calculations such as standard deviations, mean, variance and standard error were used.

3.7.2 Binary logistic regression (BLR).

In order to determine the awareness of climate change among the respondents, BLR was employed. This approach takes into account only two values or variables. Logistic regression is a multivariate technique analysis which can be used to study the relationship between a dichotomous dependent variable and one or more independent variables (Molla-Bauza *et al.,* 2005). The model is appropriate when attempting to model a dichotomous dependent variable.

Let Y be a binary response variable

$Y_i = 1$, Respondent is aware of climate change i

$Y_i = 0$, Respondent is not aware of climate change i

X = (X_1, X_2.....X_k) be a set of explanatory variables which can be discrete, continuous, or a combination. *Xi* is the observed value of the explanatory variables for observation *i*.

Assuming that climate change awareness is a function of household gender (X_1), household age (X_2)……..…. X_n. The initial model will be given as:

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \ldots\ldots + \beta_k x_k + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.4)$$

Where:

The variable Ɛ is called the error term or disturbance. It is termed "noise" reflecting other factors that influence climate change awareness. It captures the factors other than X affecting Y.

Y = dependent variable

X = independent variables

βi = regression coefficients

α = is the constant term

The model for logistic regression analysis assumes that the outcome variable, Y, is categorical (e.g., dichotomous). Hypothetically, population proportion of cases for which Y = 1 is defined as p = P (Y =1). Then, the proportion of cases for which Y = 0 is 1 - p = P (Y = 0). In the absence of other information, we can estimate p by the sample proportion of cases for which Y = 1. However, in the regression context, it is assumed that there is a set of predictor variables, X_1…....X_k, that are related to Y and, therefore, provide additional information for predicting Y.

$$\text{Logit}(P_i) = \ln(P_i / 1\text{-}P_i) = \alpha + \beta_1 X_1 + \ldots + \beta_n X_n + U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.5)$$

Where:

$\ln(P_i / 1\text{-}P_i)$ = logit for farmers awareness (Yes or No)

P_i = Farmers who are aware;

1 - P_i = Farmers who are not aware;

β = coefficient

X_1 = covariates

U_t = error term

Then, the logistic regression model can be expressed as:

$$\text{Logit}(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0+\beta_1 X_i \quad \text{.. (3.6)}$$

$$\pi i = \frac{exp(\beta 0+\beta 1xi)}{1+exp\ (\beta 0+\beta 1xi)} \quad \text{..(3.7)}$$

When the variables are fitted into the model, the model is presented as:

$$\ln (P_i / 1\text{-}P_i) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots .. + U_t \quad \text{..................................(3.8)}$$

3.7.3 Principal component analysis and Tobit regression.

Principal Component Analysis (PCA) and Tobit regression analysis were used to identify factors that influenced climate change among the respondents in the study area.

(a) Principal component analysis

PCA is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. It defines a new orthogonal coordinate system that optimally describes variance in a single dataset, and it is sensitive to the relative scaling of the original variables. With a large number of variables, the dispersion matrix may be too large to study and interpret properly. There would be too many pairwise correlations between the variables to consider. To interpret the data in a more meaningful form, it is, therefore, necessary to reduce the number of variables to a few interpretable linear combinations of the data. Each linear combination will correspond to a principal component. This transformation is expressed in such a way that the first principal component has the largest possible variance and each succeeding component, in turn, has the highest variance possible under the constraint that it is orthogonal to the preceding components. The number of principal components is less than or equal to the smaller of the number of original variables or the number of observations.

The results of a PCA are usually discussed in terms of component scores, sometimes called factor scores or factor loadings. Data set can be deconstructed into eigenvectors and eigenvalues. Eigenvectors and eigenvalues exist in pairs and every eigenvector has a corresponding eigenvalue. An eigenvector is a direction while an eigenvalue is a number that shows how much variance there is in the data in that direction. The eigenvector with the highest eigenvalue is, therefore, the principal component, where the eigenvector with the lowest eigenvalue contains less information which cannot be retained.

Mathematically, PCA is defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by some projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. Mathematically, the transformation is defined by a set of p-dimensional vectors of weights or loadings: $w_{(k)} = (w_{1,\ldots\ldots\ldots\ldots,} w_p)_{(k)}$ that map each row vector $x_{(i)}$ of X to a new vector of principal component scores $t_{(i)} = (t_{1\ ,,,\ldots\ldots\ldots\ldots,} t_n)_{(i)}$,

Given by $t_{k(i)} = x_{(i)}.\ w_{(k)}$ for *i= 1, ……, n* *k = 1, ……, m*

Assuming we are converting a set of original data set or variables into X_j (j=1, 2, k) into a new set of uncorrelated variables called principal components, PCI (I=1,2..., k), which were linear combinations of original variables (Koutsoyiannis, 1972).

Consider the linear combinations

$PC_1 = a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots + a_{1K}X_K$ ……..... (3.9)

$PC_2 = a_{21}X_1 + a_{22}X_2 + \ldots\ldots\ldots + a_{2K}X_K$ ……..... (3.10)

$PC_3 = a_{31}X_1 + a_{32}X_2 + \ldots\ldots\ldots + a_{3K}X_K$……..... (3.11)

$PC_K = a_{K1}X_1 + a_{K2}X_2 + \ldots\ldots\ldots + a_{KK}X_K$ ……..... (3.12)

Where PC_1 = the *i*th principal component,

aij = component loadings (coefficients)

And Xj = original variables.

Thus, the linear combinations give rise to: first principal component (PC_1) accounts for the maximum possible proportion of the total variation in the Xj's, the second principal component

(PC_2) accounts for the maximum of the remaining variation (variance) in the Xj's and so on. In this manner we have: var (PC_1) ≥ var (PC_2) ≥ var (PC_3) ≥… ≥ var (PC_P), where var (PC_1) expresses the variance of PC_1 in the data set being measured.

(b) Tobit regression

The Tobit model, also called a censored regression model, was employed to estimate linear relationships among variables when there is either left or right-censoring in the dependent variable. In other words, the factors influencing climate change adaptation in the study area were estimated using Tobit regression analysis. The model was developed by Tobin (1958). The adaptation to climate change is the dependent variable. It was targeted at evaluating the effect of numerous endogenous variables on the extent of adaptation strategies adopted by each respondent. Following Schwarze (2004), since the dependent variable is bounded between 0 and 1 (i.e, the variables are censored at 0.0 and 1.0), conventional regression methods fail to take into account the qualitative difference between zero and continuous observations. Furthermore, Rhaji (2000), opined that Tobit model combines the properties of multiple regression and Probit/Logit model. Therefore, Tobit model which was initially established for censored data was applied for the analysis. The model is specified as:

$Y_i = \beta Xiifi^* = \beta Xi + ui > Ti$ ……..……..(3.13)

$Y_i = \beta 0 + \beta iXi + ui$ ……..……...…(3.14)

Where:

uí = normally distributed with zero mean and constant variance

X_i = vector of explanatory variables

βi = vector of the parameter estimate

The model is fully estimated as follows:

$yi^* = \beta 0 + \beta 1xi + \varepsilon i = xi'\beta + \varepsilon i$, $\varepsilon i \sim N(0,\sigma 2)$…….……(3.15)

If $y_i^* > 0$ => y_i = climate change = $y_i^* = x_i'\beta + \varepsilon_i$. …….……..….. (3.16)

If $y_i^* \leq 0$ => $y_i = 0$(y* can be negative, but if it is, y=0)…….…….…… (3.17)

Probability Model --$\varepsilon_i \sim N(0, \sigma^2)$……..…..…….……..(3.18)

$Prob(y=0|x) = Prob(y^* \leq 0|x) = Prob\ [(y^*- X\beta)/\sigma \leq (0- X\beta)/\sigma|x]$…….……..……... (3.19)

$Prob[z \leq - X\beta/\sigma|x] = \Phi(-X\beta/\sigma) = 1- \Phi(X\beta/\sigma)$……..…….……...(3.20)

$$Prob(y>0|x) = Prob(y^* > 0|x) = 1- \Phi(-X\beta/\sigma) = \Phi(X\beta/\sigma)\text{.....(3.21)}$$

Yi = Climate change adaptation strategies index determined by dividing the number of climate change adaptation strategies used by the individual farmers by all the climate change adaptation strategies available in the study area. Thus, the value of the climate change adaptation strategies index ranges between zero (0) and one (1). Thus, the explanatory variables used in the analysis include the socioeconomic variable of the household head and information pertaining to climate change and its adaptation, which are:

X_1 = Number of years of farming (years)

X_2 = Farm size (hectares)

X_3 = Household size (number of persons in the household)

X_4 = Gender of household head (Male = 1; Female = 0)

X_5 = Age of household head (years)

X_6 = Marital status

X_7 = Household head educational level

X_8 = Household head source of income (R)

X_9 = Type of farm

X_{10} = Who manage the farm

X_{11} = Who owns the farm

X_{12} = Land acquisition

X_{13} = Climate change awareness

X_{14} = Information receive on climate change

X_{15} = Source of climate change information

X_{16} = Climate change information through extension services

X_{17} = Channel of information on climate change

X_{18} = Support received on climate change

X_{19} = Climate change adaptation

X_{20} = Adaptation barrier

3.7.4 Two stage least square regression

Lastly, a two stage least square regression was used to analyse the effect of climate change on respondents' livelihood in the study area. Two stage least square is a method of estimating a causal

effect in the instrumental variables settings. It involves running Ordinary Least Square (OLS) twice. In the first stage, two stage least square (TSLS) finds the portions of the endogenous and exogenous variables that can be attributed to the instruments. This stage involves estimating an OLS regression of each variable in the model on the set of instruments. The second stage is a regression of the original equation, with all of the variables replaced by the fitted values from the first-stage regressions. The coefficients of this regression are the TSLS estimates. The predicted values from these regressions replace the original values of the endogenous variables in the second stage regression model.

Mathematically written:

Assume we want to estimate the coefficients of the linear model

$$Y_I = \beta_\circ + \beta_1 X_{1I} + \ldots\ldots\ldots\ldots + \beta_k X_k + \varepsilon i \quad (3.22)$$

But some of the variables X_{ji} are correlated with the error term. OLS estimation of this equation will be biased and inconsistent. Suppose that we have a collection of q > p instruments, $Z_{1i}. . . Z_{qi}$. The two-stage least squares estimator of β will be as follows:

Regress each X_j on Z and save the predicted values, X_j. If X_j is included in Z, we will have $\hat{X}_j = X_j$. Estimate β via the OLS estimate of the regression model

$$Y_I = \beta_\circ + \beta_1 \hat{X}_{1I} + \ldots\ldots\ldots\ldots + \beta_k \hat{X}_{kI} + \varepsilon i \quad (3.23)$$

3.8 Ethical consideration and respondents' consent to collect data

Ethical clearance was obtained from the College's Ethics committee. Permission from local authorities and consent from respondents to collect data were obtained before the start of the interviews. The respondents' information was kept private and confidential. Mutual respect was accorded to all the respondents.

3.9 Limitations of the study

One of the limitations of the study is that the outcome of the research may not reflect the entire situation in the Province, as data were collected in one district municipality of the Province. The study was limited to one district municipality with 5 local municipalities and data samples were collected and conducted between the months of October and December 2016. Lack of information was a challenge during the course of collecting data in this research as some of the respondents did not have a proper record. They only relied on memory which could be prone to error.

3.10 Summary

In this chapter, research design, sample size and selection procedure were explained. Sampling, data collection and tools of collecting data, data capturing and data analysis were equally elucidated. The different models used and motivation for their usage in the study were extensively discussed. The next chapter presents research results, findings, and the discussions.

CHAPTER FOUR
SOCIO-ECONOMIC CHARACTERISTICS OF FARMING HOUSEHOLDS AND ADAPTATION MEASURES

4.1 Empirical results and discussion

This chapter presents the descriptive analysis results of the respondents in the study area across the district municipality showing the socio-economic characteristics. The chapter also expatiates on the results of the climate change related information as well as adaptation measures used by the respondents. In addition, the chapter relays the descriptive statistics of the household livelihood in response to the impact of climate change.

4.2 Socio-economic characteristics of respondents in the study area

4.2.1 Frequency distribution of respondents across the local municipalities

The distribution of respondents according to the local municipalities in the study area is presented in Table 4.1. The following local municipalities were visited: Tswaing, Ditsobotla, Mahikeng, Ratlou, and Ramotshere Moiloa. The results demonstrated that majority of the respondents were from Tswaing local municipalities with 132 households, with a ratio of 38.2 percent, followed by Ditsobotla local municipalities, where the respondents numbered 109, thus attracting a percentage of 31.5. On the other hand, Ratlou and Ramotshere Moiloa local municipalities had the least number of respondents: 15 and 10 respectively, with corresponding percentages of 4.3 and 2.9.

4.2.2 Frequency distribution of respondents according to number of years in farming

As represented in Table 4.1, a total of 6.6 percent of the respondents had been farming for 5 years or less across the study area, while majority of the respondents had been in farming business between 6 and 10 years, and others between 11 and 15 years which accounted for 26.6 and 25.5 percent respectively. However, the more the number of the years in farming, the fewer the number of the respondents were found in the study area. Given this, the results indicated that households were diverting their livelihoods from agricultural activities to mining industries.

It was however observed that, the impact of climate change on maize farming must have contributed to the decrease of individuals planting maize which resulted in crop diversification to soybeans for instance. This was confirmed by Matji (2015), who reported that changes in climatic conditions have a significant impact on the distribution of maize in South Africa. Furthermore, there is an urban migration, which evidenced that household members move from rural areas to look for better opportunities in the city, thus, decreasing the number of years of farming in the study area.

4.2.3 Frequency distribution of respondents according to farm size

Distribution of respondents according to the farm size is presented in Table 4.1. The result depicted that majority of the respondents (41.9 percent) in the study area occupied and cultivated about 51–100 hectares of land, while most of the farmers are from Tswaing local municipality. The reason for large farm size for maize production is not far-fetched from the fact that, North West Province (Ngaka Modiri Molema District Municipality) is one of the largest maize producing areas in South Africa. This is confirmed by The South African Agricultural Baseline study (2011) and Bureau for Food and Agricultural Policy (BFAP, 2007). According to NWDC (2016), the province is an important food basket in South Africa.

4.2.4 Frequency distribution of respondents according to household size

Table 4.1 presents the distribution of respondents according to the household size. The results showed that the household size of a larger percentage of the respondents was between the number of four (4) and six (6), with a percentage of 40.2 percent. This was followed by the group who had between 1 and 3 household size, with a consequent 31.2 percent. This depicts that the average household size in the study area was of medium size. However, it is likely that a larger number of household size can be used as a source of manual labour on the farm. Contrarily, Mano and Nhemachena (2006), argued that large household size tends to divert part of its labour force into non farming activities.

4.2.5 Frequency distribution of respondents according to gender

The distribution of respondents according to the gender is shown in Table 4.1. The examination denoted that most of the respondents were male (84.1 percent), while majority were from Tswaing local municipality. On the other hand, the female respondents were only a fraction of 15.9 percent

in the study area. Thus, this finding confirmed the notion that farming was predominantly for male whereas the female were known for selling the agricultural produce and processing it. The result is in line with FAO's (2011) submission on rural employment and farm labour project; it was reported that with regard to farming, men proved more productive than their female counterparts. Oduniyi's (2014) findings also corroborated this point of view because it ascertained that, depending on cultural norms, some farming activities, such as ploughing and spraying, relied on access to male labour without which women farmers face delays that may lead to losses in farm produce. Correspondingly, Ajani and Ashagidigbi (2008), buttressed that majority of the farmers in Ondo State, Nigeria, were male.

4.2.6 Frequency distribution of respondents according to age

The distribution of respondents according to age is shown in Table 4.1. The result revealed that majority of the farmers fall within the age group of 51 - 60 which accounted for 34.7 percent. This depicts that the young people in the study area are not involved in farming; rather they are engaged in different activities especially in the area of information technology, tendering and mining (Oduniyi, 2014). This is supported by Maponya and Mpandeli (2012), whose findings verified that youth in the communities are involved in other activities.

4.2.7 Distribution of respondents according to marital status

The results in Table 4.1 showed that 194 out of the 346 respondents were married, with a parallel of 56.1 percent, single totaled 90, with a ratio of 27.7 percent, the divorced numbered 27, with a tally of 7.8 percent, the widowed were 14 in number, with an aggregate of 4.0 percent, and only 4.3 percent were separated, and they numbered 15. Thus, the investigation demonstrated that marital status can influence the extent of the household's livelihood and can also affect the level of climate change awareness and adaptation through the knowledge of the household head. The findings explained that farming is done mostly among the married people. This is supported by Titus *et al.* (2015), who reported that agriculture is primarily practiced by married people.

4.2.8 Distribution of respondents according to the level of education

Table 4.1 displays the educational status of the farming households' heads in the study area. The result showed that majority of the household heads, totaling 119, with an equivalent 34.4 percent completed standard 5; 91 had between standard 6 and 10, with a percentage of 26.3; 27 attended

higher education, affording it a proportion of 7.8 percent; 11 went to pre-school, ranking it a ratio of 3.2 percent; those who had sub standard education were 30, with an equivalent 8.7 percent, while a significant number of 68 had no formal education (19.7 percent). The level of education can improve the households' livelihood, knowledge towards adoption and better farming practices. However, educational level of the respondents influences climate change adaptation, awareness, and livelihood strategies. The more knowledgeable the household head, the better informed, regarding more awareness on climate change and adapted the rest of the household members would be. The same finding was reported by Maddison (2007), who emphasized that farmers who have experience and education are anticipated to possess more information and understanding related to climate change and adaptation. Also, a report by (Asfaw and Admassie, 2004; Bamire *et al*., 2002) explained that in any given resources, the capacity of the farmer to produce depend on how much education and information acquired.

4.2.9 Distribution of respondents according to major income

The distribution of respondents according to farming being a major source of income as shown in Table 4.1 revealed that a total number of 244, which is equal to 70.5 percent of the respondents, derived their income and livelihood mainly from farming, while the remaining 102, with a corresponding 29.5 percent reported otherwise. The finding indicated that agriculture provides the major source of revenue for the households in the study area. This result maintained uniformity with IFAD's (2011) findings that about 80 percent of rural households engaged in farm activities of some sort, while only 10 to 20 percent of rural households in sub-Saharan Africa derived their income from the non-farm economy.

4.2.10 Distribution of respondents according to types of farm

Table 4.1 communicates the distribution of respondents according to types of farm. The result indicated that majority operated an individual farm: 184, equating it with 53.2 percent; those who farmed on family farms were 50 and an equivalent 14.5 percent; those who utilise community farm were 66 in number, making the aggregate 19.1 percent; however, those who operated a tribal farm, accounted for 13.3 percent, with an even number of 46. This implies that individual farms are well managed, compared to other farm types, as individual farms have to generate enough produce to sell in other to meet family needs and sustain a livelihood.

4.2.11 Distribution of respondents according to who manages the farm

Table 4.1 shows the distribution of respondents according to who manages the farm. The result revealed that majority of the farms are managed individually: 336, with a parallel 97.1 percent, while a frequency of 8 and a matching 2.3 were identified under family members; only 2, with a fraction of 0.6 percent of the farms were managed by the group of farmers. This suggests that individual farmers prefer to manage their farms themselves as to monitor the effect of climate change on their crop yield.

4.2.12 Distribution of respondents according to who owns the farm

Table 4.1 evinces that majority of the farms were owned by the individuals: 85.8 percent, summing up to 297. However, while 37 (10.7 percent) were owned by family members; 6 each (1.7 percent) belonged to farmers' group and corporation or company farm. This implies that individuals are the major farm owners, which means adoption of technologies and changes in livelihood strategies becomes easier especially if it is tied to the land. This finding is supported by Maponya (2012), where farm ownership is controlled mostly by the individual farmers in Limpopo Province of South Africa.

4.2.13 Distribution of respondents according to land acquisition

The distribution of respondents according to land acquisition as shown in Table 4.1, indicated that majority of the respondents (39.3 percent) acquired their farms through land redistribution for agricultural development (LRAD), 30.9 percent of the respondents acquired their farms through land affairs, and 14.5 percent of the respondents inherited the farm while about 8.7 percent of the household hired their farmlands.

Table 4.1 Socio-economic characteristics of respondents in the study area

Variables	%	Frequency	Mean	Std Dev.	Variance
Local Municipalities			2.020	1.024	1.049
Tswaing	38.2	132			
Ditsobotla	31.5	109			
Mahikeng	23.1	80			
Ratlou	4.3	15			
Ramotshere Moiloa	2.9	10			
Number of Years of Farming			3.62	1.852	3.332
≤ 5	6.6	23			
6 – 10	26.6	92			
11 – 15	25.4	88			
16 – 20	14.2	49			
21 – 25	3.8	13			
26 – 30	16.8	58			
31 – 35	3.2	11			
36 – 40	3.5	12			
Farm Size			2.98	1.290	1.633
≤ 50	1.4	5			
51 – 100	41.9	145			
10 – 150	33.8	117			
151 – 200	13.6	47			
201 – 250	3.5	12			
251 – 300	3.5	12			
301 – 350	0 .6	2			
351 – 400	1.4	5			
450 – 500	0.3	1			
Household Size			2.13	1.073	1.151
1-3	31.2	108			
4-6	40.2	139			
7-9	17.9	62			
10-12	5.8	20			
13-15	4.9	17			
Household Gender			1.16	0.366	0.134
Male	84.1	291			
Female	15.9	55			
Household Age			3.45	1.432	2.051
21-30	11.3	39			
31-40	19.7	68			
41-50	17.6	61			
51-60	16.2	56			
61-70	34.7	120			
71-80	0.6	2			
Marital Status			2.01	0.954	0.901
Single	27.7	96			
Married	56.1	194			
Divorced	7.8	27			
Widowed	4.0	14			
Separated	4.3	15			
Level of Education			3.86	1.351	1.826
Pre-school	3.2	11			
Sub Standard A & B	8.7	30			
Standard 1 -5	34.4	119			
Standard 6 -10	26.3	91			
Higher	7.8	27			
None	19.7	68			
Faming as Major Income			1.29	0.457	0.208
Yes	70.5	244			
No	29.5	102			

Source: Field Survey (2016)

Table 4.1 Socio-economic characteristics of respondents in the study area (continue)

Variables	%	Frequency	Mean	Std Dev.	Variance
Type of Farm			2.06	1.386	1.921
Individual Farm	53.2	184			
Family Farm	14.5	50			
Community Farm	19.1	66			
Tribal Farm	13.3	46			
Who Manage the Farm			1.03	0.213	0.045
Individual	97.1	336			
Family Members	2.3	8			
Farmers Group	0.6	2			
Who owns the Farm			1.19	0.544	0.296
Individual	85.8	297			
Family Members	10.7	37			
Farmers Group	1.7	6			
Corporation/Company Farm	1.7	6			
Land Acquisition			5.09	2.048	4.194
Own Finance	2.6	9			
LRAD	39.3	136			
PLAS	4.0	14			
Inheritance	14.5	50			
Land Affair	30.9	107			
Hire	8.7	30			

Source: Field Survey (2016)

4.3 Climate change related information in the study area

4.3.1 Distribution of respondents according to climate change awareness area

The distribution of respondents in regard to climate change awareness in the study area is presented in Table 4.2. The result revealed that majority of the respondents, specifically 318 (91.9 percent) were aware of climate change, while only 28 (8.1 percent) of the respondents claimed unawareness. This indicates that farmers had perceived climate change which enhances their awareness. This is not surprising because different sources pertaining climate change information, awareness and practices are being shared among the farmers in the recent years. This is confirmed by Idrisa *et al.* (2012), who reported in a study conducted in Sahel Savannah agro-ecological zone of Borno State, Nigeria, that the majority of farmers were aware of climate change and its consequences.

4.3.2 Distribution of respondents according to information received on climate change

Table 4.2 presents the result of the distribution of the respondents according to the information received. Majority of the respondents: 340, affording it a ratio of 98. 3 percent revealed that they receive information on climate change in the study area. Contrastingly, only 1.7 percent, an equivalent of 6 of the respondents received no information on climate change. The implication is

that most household farmers in the study area are aware of climate change which enables them to adapt as expected.

4.3.3 Distribution of respondents according to source of information on climate change

The source of information on climate change as presented in Table 4.2 evidenced that most of the respondents, 305 in number, corresponding to 88.2 percent, sourced information on the radio. Respondents who sourced information from local newspapers and extension officers were 2.9 percent and 2.3 percent, with matching numbers of 10 and 8 respectively, while 11, with a parallel 3.2 percent of the respondents received or had no source of information on climate change. These findings are supported by Maponya (2012), who reported that local radio is the major source of information received by small-scale farmers in the Limpopo Province of South Africa.

4.3.4 Distribution of respondents according to information on climate change through extension services

The information received on climate change through extension officers as shown in Table 4.2, revealed that most of the respondents, a total of 262, an equivalent 75.7 percent received information on climate change through extension service, while 24.3 percent of the respondents, which equals 84 received no information through extension services. This has a positive influence as extension services enhance climate change adaptation, awareness and helps livelihood strategies. Congruently, Apata *et al.* (2009), Deressa *et al.* (2010) and Bryan *et al*. (2009), observed that access to extension services had a strong positive influence on adapting to climate change. Nhemachena (2007), also noted that exposure to extension services influenced the capacity of farmers to adapt to climate change and increases awareness of climate change.

4.3.5 Distribution of respondents according to channel of information on climate change

The distribution of respondents according to information channel received on climate change is shown in Table 4.2. The investigation demonstrated that the major channel of information through which farmers are acquainted with the knowledge they need on climate change is via oral communication within the farmers themselves (from farmers to farmers). Thus, the number of respondents ranked highest: 268, which accounted for 77.5 percent. Next in the ranking order are those who receive information through formal extension channel; the frequency is 54, assigning it a parallel 15 percent; this is followed by those who do not even receive information on climate

change, they numbered 16, affording them a quotient of 4.6 percent; while the least placed, are those who receive information from municipality office; 8, with a corresponding 2.3 percent. Subsequently, given that farmers share information on climate change signifies cooperation and this has a positive influence on farmers' decision and adoption. Information shared through farmer to farmer go a long way to impact farmers' livelihood, as it identifies and tackles the felt needs of the farmers, and functionally boost production.

4.3.6 Distribution of respondents according to support received on climate change impacts

Table 4.2 shows the distribution of respondents according to support received on the impacts of climate change. The results indicated that farmer to farmer extension is the support mostly received on the climate change impacts, hence the number was 117, giving it a proportion of 33.8 percent. However, majority of the respondents, numbering 180, an aggregate of 52 percent of them reported that they received no support on the impact of climate change while only 11.6 percent of the respondents, that is, a total of 40 received formal credits support. The numbers of those who receive support from insurance, relatives and subsidies were 3 (0.9 percent), 2 (0.6 percent) and 4 (1.2 percent) respectively. The support received on climate change has a positive influence on livelihood and climate change impact, as it takes care of the risk involves on the impact and improve livelihood. Nevertheless, the survey showed that more than half of the farmers received no support, and this will adversely affect their livelihoods. This outcome is also reflected in the study carried out by Kandlinkar and Risbey (2000), for they contend that most farmers in Africa operate under resource limitation.

Table 4.2 Climate change related information in the study area

Variables	%	Frequency	Mean	Std Dev.	Variance
Awareness made			1.08	0.273	0.075
Yes	91.9	318			
No	8.1	28			
Information on Climate Change			1.02	0.131	0.017
Yes	98.3	297			
No	1.7	37			
Source of Information			3.25	0.897	0.805
Flyers	0.6	2			
Magazines	0.6	2			
Radio	88.2	305			
Local Newspapers	2.9	10			
Internet	2.3	8			
Extension Officer	2.3	8			
None	3.2	11			
Information on Climate Change through Extension Service			1.24	0.429	0.184
Yes	75.7	262			
No	24.3	84			
Channel of Information Received on Climate Change			2.14	1.226	1.504
Formal Extension	15.6	54			
Farmer to Farmer	77.5	268			
Municipality Office	2.3	8			
None	4.6	16			
Support Received on Climate Change Impacts			4.87	2.316	5.366
Formal Credit	11.6	40			
Insurance	0.9	3			
Farmer to Farmer Extension	33.8	117			
Relatives	0.6	2			
Subsidies	1.2	4			
None	52.0	180			

Source: Field Survey (2016)

4.4 Adaptation strategies among the respondents in the study area

4.4.1 Distribution of respondents according to climate change adaptation

The proportion of adaptation to climate change is shown in Table 4.3 below. The result of the research showed that 94.2 percent of the respondents, a total of 326 out of 346, adapted to climate change while few respondents, numbering 20, which equals5.8 percent admitted that they could not adapt. Considering the large number of those who professed to adopting strategies to manage climate change, it signifies that rural household farmers engage in adaptation strategies to cope with climate change incongruities. For instance, Gibbons and Ramsden (2008), acknowledged that the impact of climate change on agricultural enterprises is much dependent on available adaptation options.

Table 4.3: Distribution of respondents according to climate change adaptation

Climate Change Adaptation	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	326	94.2	94.2	94.2
No	20	5.8	5.8	100.0
Total	346	100.0	100.0	

Source: Field Survey (2016)

4.4.2 Distribution of respondents according to climate change adaptation measures

Table 4.4 delineates the distribution of respondents according to the climate change adaptation measures. Though there were various adaptation strategies used by the farmers in the study area, most of the strategies were targeted towards drought, and this is because increased temperature is the most perceived element in the study area. As a result, a greater aggregate of the respondents (37.3 percent) engaged in minimum tillage to adapt to climate change impact, followed by crop rotation measures (8.1 percent), planting tolerance maize seeds (4.9 percent), changing of planting date (4.9 percent), change to drought tolerance crop (3.8 percent) while few of the respondents (5.5 percent) did not adopt any measure to adapt to climate change. Adaptation plays a significant role in order to improve livelihood and food production because it is a process of acclimatization; as such minimum tillage is widely adopted in the study area to adapt to climate change. About 37.3 percent of the farmers in the study area practiced minimum or zero tillage to coop in drought by conserving soil moisture content and preserving soil organic carbon.

Minimum tillage is considered to be an environmentally agricultural practice which helps to enhance the soil arrangement. It is one of the practices used in conversation agriculture to promote sustainability. Maponya and Mpandeli (2012), attested to this, for they reported that farmers from Limpopo engaged in minimum tillage to coop in drought. This finding is also confirmed by Marenya *et al.* (2017), minimum tillage combined with mulching is critical to conservation agriculture, used by smallholder farmers in climate change adaptation. Thierfelder *et al.* (2012), also hold forth that smallholder farmers preferentially adopted the no-tillage or minimum soil disturbance component as a means of adapting to climate change impacts. Still, Ajani *et al*. (2013), remarked that in Nigeria, adaptation strategies perceived by farmers include: crop diversification, different crop varieties, changes in planting dates, soil conservation techniques and shortening the

length of growing season. Local farmers in sub-Saharan Africa have been known to conserve soil carbon through the use of minimum tillage practice (Schafer, 1989; Osunade, 1994). Furthermore, from the result, it was shown that about 1.4 percent of the farmers practiced crop diversification, an evidence that most farmers' adaptations to climate change and variability were centered on diversification.

Another adaptation strategy from the study was the planting of different crops. About 4.3 percent were involved in planting different crops to adapt to climate change. The reason behind this can be attributed to the belief that if one crop fails to sustain a living, the other crops can still generate the needed income for livelihood maintenance; this could possibly be termed as crop risk. On account of this, many studies revealed that farmers reconsidered and grown different crops varieties in response to perceived changes in temperature and rainfall. For example, Kenyan farmers switched to cassava, sweet potatoes, and pigeon peas (Bryan *et al.,* 2013). Cassava, in particular, is potentially useful for adaptation to climate change in SSA, because it grows in marginal soils, tolerates prolonged periods of drought and heat, and is left in the ground until needed (Jarvis *et al.,* 2012). Malawian farmers moved to cassava growing areas during the 2001/02 famine (Brooks, 2014). According to Bryan *et al.* (2009), noted that the important factors permitting crop switching are access to irrigation and to extension information.

In the same vein, few of the farmers were planting improved seeds. About 4.9 percent of the farmers engaged in plant tolerant maize seeds. Research in SSA revealed an advantage of constant yield of improved maize cultivars over local maize cultivars under different rainfall condition at different levels of fertilizer use (Smale and Jayne, 2003). Furthermore, in Nigeria, Tambo and Abdoulaye (2013), equally reported that accessibility to improved drought tolerant varieties increased the yield of maize production.

The study also observed that a change to drought-tolerant crops such as sunflowers was also practiced. Switched to varieties of crops that are less sensitive to climatic stress and shock is one of the preferred strategies used by farmers in SSA. The study reviewed that about 3.8 percent of the farmers switched to drought tolerance crops. This is in accordance with Fisher *et al.* (2015), who reported that policymakers also support this approach.

Likewise, Crop rotation strategies were adopted by about 8.1 percent of the farmers. The strategies play important roles for increasing maize production in the study area. The result showed similar report with other recent studies. Crop rotation or switching crops was still found to have an influence on maize productivity (Kuntashula *et al.,* 2014). In Tanzania, farmers diversify into planting various types of crops such as in a form of rotation as a way of preventing or minimizing risks on the farm (Orindi and Eriksen, 2005; Adger *et al.,* 2003). This serves as an insurance against climate variability.

Changing the planting dates is another adaptation strategy. About 4.9 percent of the farmers used this method in the study area. According to Reason *et al. (*2005), the beginning of the rainy season is essential to the planting time or date of rain fed crops. In other words, soil moisture might not be enough for germination of the seed during early planting, whereas, heavy rainfall tends to wash away the seed in the soil during late planting. In SSA, farmers reported a shift in planting dates as a coping mechanism.

However, some strategies from Table 4.4 are combined by the farmers to adapt to climate change. For example, while some farmers adopted a combination of crop diversification, plant tolerant maize seeds, and change to drought-tolerant crops, others preferred a combination of planting of maturity cultivars and shortening the growing period.

Table 4.4: Distribution of respondents according to climate change adaptation measures

Adaptation Measures	Frequency	Percent	Valid Percent	Cumulative Percent
Minimum or Low Tillage	129	37.3	37.3	37.3
Crop Diversification	5	1.4	1.4	38.7
Plant Different Crops	15	4.3	4.3	43.1
Plant Tolerant Maize Seeds	17	4.9	4.9	48.0
Change to Drought Tolerance Crops	13	3.8	3.8	51.7
Crop Rotation	28	8.1	8.1	59.8
Changing of Planting Date	17	4.9	4.9	64.7
Reduced Cultivated Land	5	1.4	1.4	66.2
Ripping Deeper and Ploughing Every Year	14	4.0	4.0	70.2
Prayers	6	1.7	1.7	72.0
Improved Land Magt	7	2.0	2.0	74.0
Change of Production Practices	1	0.3	0.3	74.3
Combination of 2, 3 & 5	38	11.0	11.0	85.3
Combination of 11 & 12	32	9.2	9.2	94.5
None	19	5.5	5.5	100.0
Total	346	100.0	100.0	

Source: Field Survey (2016)

4.5 Impact of climate change on livelihoods of respondents in the study area

4.5.1 Distribution of respondents according to climate change impacts on livelihood

The distribution of the respondents according to the impacts of climate change on livelihood is shown in Table 4.5. The result portrayed that majority of the respondents (99 percent) reported an impact of climate change on their livelihood, which includes increased socio-economic problems, low-income, and increased unemployment. However, the minority of the respondents (only 1 percent) claimed there was no impact of climate change on livelihood. This implies that climate change is not only linked to livelihood, but also threatened it.

4.5.2 Distribution of respondents according to climate change impacts on most affected livelihoods.

Table 4.5 is a graphic picture of the distribution of respondents according to the livelihood capitals affected most by the impact of climate change. As shown in the table, natural capital livelihood was affected most; as such it had a frequency of 134, which accounted for 38.7 percent of the respondents. Next in the order of hierarchy is financial capital livelihood, numbered 91, affording it a ratio of 26.3 percent, followed by human capital livelihood, with a total of 68, equivalent to 19.7 percent, after that is the social capital livelihood, totaling 28, with an equivalent 8.1 percent; the least ranked in the categorization is physical livelihood: 25, with a parallel of 7.2 percent. Consequently, the investigation shows that climate change had more negative impact on natural capital livelihood, followed by financial capital livelihood.

4.5.3 Distribution of respondents according to the extent of impacts on livelihood

Majority of the respondents (73.4 percent) in Table 4.5 reported a severe impact of climate change on livelihood. Low impact and high impact accounted for 2 percent and 24.6 percent of the respondents respectively. The implication is that the impact of climate change is severe on livelihood. The findings are in line with Dinar *et al*. (2008), who reported that livelihoods suffer severe losses as a result of changes in climatic conditions in the region of Africa, Zimbabwe inclusive.

4.5.4 Distribution of respondents according to impact of climate change on farm income

The distribution of respondents according to the impact of climate change on farm income is shown in Table 4.5. Majority of the respondents, 232, corresponding to 67.1 percent, reported low farm income as a result of the impact of climate change, while 114, an aggregate of 32.9 percent reported otherwise. Subsequently, the result indicated that the impact of climate change reduces farm income. This standpoint is in agreement with findings of Kurukulasuriya and Mendelsohn (2008). The researchers predicted declines and setback in Southern Africa over net crop income.

4.5.5 Distribution of respondents according to impact of climate change on loan repayment

Table 4.5 revealed the distribution of respondents according to the impact of climate change on loan repayment. Out of 346 respondents, 271, which equaled 78.3 percent, which constituted majority of the farmers who had been affected by the climate change reported failure to pay back

the loan as there was no income to pay back. However, 75, which matched up to 21.7 percent, representing a few of the respondents were able to repay their loans. The inference is that the impact of climate change affects the famers, because most of them could not repay their loans as crop yield is low which resulted into little or no profit.

4.5.6 Distribution of respondents according to impact of climate change on credit accessibility

Accessibility to credit by the respondents are shown in Table 4.5, where the majority of the farmers (67.9 percent) had no access to credit due to the negative impact of climate change as climate variability and events pose risk and uncertainties on farming activities. Oppositely, about 32.1 percent of the respondents reported accessibility to credit in the face of climate change. This shows that rural livelihood is threatened as a result of inaccessibility to credit.

4.5.7 Distribution of respondents according to impact of climate change on cooperate finance

The impact of climate change on cooperative finance as shown in Table 4.5, revealed that majority of the respondents (69.7 percent) could not obtain cooperate finance, as a result, climate change and its risk. Conversely, only a few respondents (30.3 percent) stated otherwise. This implies that climate change had impact on cooperative finance for it hinders the rural households from getting finance from the group as farmers could not pay back.

4.5.8 Distribution of respondents according to impact of climate change on money lender finance

The distribution of the respondents according to the impact of climate change on money lender finance is shown in Table 4.5. It was revealed that, as a result of climate change impact, most farmers (80.6 percent) could not obtain finance from money lender. Nonetheless, few respondents (19.4 percent) stated otherwise. The risk and uncertainty involve in climate change prevent moneylenders from offering loans to the rural household farmers as they are not sure of the future climatic condition and its impact on agriculture.

4.5.9 Distribution of respondents according to impact of climate change on personal savings

The impact of climate change as shown in Table 4.5 had a negative impact on the farmers' savings. Climate change scenario prevented farmers from saving as it reduces food production. Majority of

the respondents (54 percent) reported no personal savings due to climate change impact on their farming production. Contrariwise, few of the respondents (46 percent) stated otherwise. This infers that the effect of climate change on livelihood results into low farm income which gives rise to low profit, and escalate into low production, and a consequent lack of personal savings.

4.5.10 Distribution of respondents according to impact of climate change on government subsidies

The distribution of respondents according to the impact of climate change on government subsidies are shown in Table 4.5. The result showed that majority of the respondents (64.5 percent) could not obtain government subsidies such as the drought-tolerant maize seeds. Nevertheless, few of the respondents (35.5 percent) obtained government subsidies. This suggests that there is little subsidy available for the rural farmers in the study area or inappropriate distribution if there is subsidy at all. Thus, lack of subsidy bars and prevents rural household farmers from producing maximally in order to sustain livelihood.

4.5.11 Distribution of respondents according to impact of climate change on financial institution

The impact of climate change on farmers' accessibility to a financial institution is shown in Table 4.5. Majority of the respondents (63.3 percent) could not obtain finance or loan from the bank, while only a few respondents (36.7 percent) were able to obtain a loan from the financial institution. The impact of climate change on farming production prevents farmers from obtaining finance from the bank because of the risk and uncertainties involved; however, this threatens rural livelihood.

4.5.12 Distribution of respondents according to impact of climate change on employments

Table 4.5 indicated that majority of the respondents, a totality of 197 (56.9 percent), reported that unemployment was attributed to the impact of climate change. On the contrary, 149 respondents (43.1 percent) stated otherwise. Consequentially, the difference between the numbers of those who averred that climate change is responsible for unemployment and those who denied its negative impact on employment suggests that climate change affects rural livelihood and employment rates in the study area. It was discovered that many farmers have stopped farming due to harsh climate

condition, while some had to reduce the land size, thus, they need not employ any labour, while, others were caught up in the climatic disaster leaving them no means of farming.

4.5.13 Distribution of respondents according to impact of climate change on poverty

The impact of climate change resulting from poverty is shown in Table 4.5. Most of the respondents (71.4 percent) admitted that poverty was caused by the impact of climate change on the farming area. However, few of the respondents (28.6 percent) stated otherwise. The result is as expected, as majority of the rural household farmers depend on agriculture which is sensitive to climate change for production. According to World Bank report (2015b), climate change impacts are likely to become severe widespread and irreversible, threatening poverty reduction and development.

4.5.14 Distribution of respondents according to impact of climate change on food production

The impact of climate change on food production as shown in Table 4.5 revealed that majority of the respondents, adding up to 245, a parallel of 73.4 percent claimed that climate change affects their food production. In contrast, 92, a fraction of 26.6 percent of them contradicted its effect on production output. In point of fact, Mendelsohn *et al.* (2000), predicted losses of 0.4 percent – 1.3 percent of gross domestic product (GDP) in southern Africa as a result of climate change impacts.

4.5.15 Distribution of respondents according to impact of climate change on profits

The distribution of respondents according to the profit-making being impacted by climate change is shown in Table 4.5. Climate change affected profit as reported by the majority of the respondents, a total of 253, which is equivalent to 73.1 percent, while only a few reported otherwise, hence they numbered 92, assigning it 26.9 percent. This suggests that profit is correlated and susceptible to climate change, which negatively affects livelihoods. However, majority of the rural household farmers in the study area survive through social grants.

Table 4.5 Impact of climate change on livelihood in the study area

Variables	%	Frequency	Mean	Std Dev.	Variance
Climate Change Impacts on Livelihood			1.23	0.418	0.175
Yes	99.1	343			
No	0.9	3			
Climate Change Impacts on Most Affected Livelihood			2.63	1.261	1.591
Human Capital Livelihood	19.7	68			
Natural Capital Livelihood	38.7	134			
Social Capital Livelihood	8.1	28			
Financial Capital Livelihood	26.3	91			
Physical Capital Livelihood	7.2	25			
Extent of Climate Change Impacts on Livelihood			2.71	0.495	0.245
Low	2.0	7			
High	24.6	85			
Severe	73.3	254			
Impact of Climate Change on Farm Income			1.33	0.471	0.222
Yes	67.1	232			
No	32.9	114			
Impact of Climate Change on Loan Repayment			1.78	0.413	0.170
Yes	21.7	75			
No	78.3	271			
Impact of Climate Change on Credit Accessibility			1.68	0.467	0.219
Yes	32.1	111			
No	67.9	235			
Impact of Climate Change on Cooperate Finance			1.70	0.460	0.212
Yes	30.3	105			
No	69.7	241			
Impact of Climate Change on Money Lender Finance			1.81	0.396	0.157
Yes	19.4	67			
No	80.6	279			
Impact of Climate Change on Personal Savings			1.54	0.499	0.249
Yes	46.0	159			
No	54.0	187			
Impact of Climate Change on Government Subsidies			1.64	0.479	0.230
Yes	35.5	123			
No	64.5	223			
Impact of Climate Change on Financial Institution			1.63	0.483	0.233
Yes	36.7	127			
No	63.3	219			
Impact of Climate Change on Employment			1.43	0.496	0.246
Yes	56.9	197			
No	43.1	149			
Impact of Climate Change on Poverty			1.29	0.453	0.205
Yes	71.4	247			
No	28.6	99			
Impact of Climate Change on Food Production			1.27	0.442	0.196
Yes	73.4	254			
No	26.6	92			
Impact of Climate Change on Profit			1.27	0.442	0.197
Yes	73.1	253			
No	26.9	93			

Source: Field Survey (2016)

4.6 Summary

This section provided a synopsis of the descriptive analysis of the socio-economic characteristics of the farming household in the study area. It identified and provided an overview of the different adaptation strategies used by the small and emerging maize farmers in the study area. Lastly, it explained the descriptive statistics of the respondents in relation to climate change and livelihood.

CHAPTER FIVE
CLIMATE CHANGE AWARENESS IN THE STUDY AREA

5.1 Introduction

This chapter expounds on the statistical results of awareness on climate change and its determinants among the farming households in the study area. The impact of climate change in Africa has been of great concern. However, before adaptation measures could take place, a deep understanding of the impact of climate change, and factors that determine awareness are needed among the rural household farmers.

5.2 Awareness of climate change among the respondents

This section presents the results of climate change awareness among the farming households in the study area. To achieve this, binary logistic regression model was employed. Firstly, Pearson correlation analysis was carried out to determine the strength of association between variables, either positive or negative, as well as the relationship between the dependent variable and the independent variables. The dependent variable (climate change awareness) was measured by means of binary variable, which is 0 if respondents are aware of climate change, and 1 otherwise.

The independent variables employed include the socio-economic characteristics and climate-related information. However, out of all the independent variables, the following variables have shown to exhibit an association with the dependent variable: farm size, level of education, land acquisition, support received on climate change are negatively associated with the dependent variable. On the other hand, marital status, who manages the farm, who owns the farm, information received on climate change, source of information on climate change, extension services were positively associated with the dependent variable. The dependent variable (climate change awareness categorized in its binary form) was regressed against the explanatory variables mentioned above.

Test for multicollinearity among the variables was carried out, showing variance inflation factor (VIF) for each variable, the mean VIF was 1.455 (See Table 5.1). Also, there occurred high level

of tolerance among the variables, which indicated that there was no serious multicollinearity among the variables used in the analysis. The value for Cox & Snell Square and Nagelkerke R Square were not statistically significant. This indicated that the data fit the model well.

Table 5.1: Multicollinearity test of variables

Variables	Collinearity Statistics	
	Tolerance	VIF
Number of years in farming	0.576	1.736
Farm size	0.725	1.379
Household size	0.762	1.313
Household gender	0.818	1.223
Household marital status	0.729	1.372
Education level	0.607	1.649
Farming as major source of income	0.566	1.768
Types of farm	0.789	1.268
Who manages the farm?	0.918	1.089
Who owns the farm?	0.791	1.265
Land acquisition	0.746	1.341
Information received on climate change	0.567	1.763
Source of climate change information	0.547	1.829
Climate change information through extension services	0.737	1.357
Channel of information received on climate change	0.745	1.342
Support received on climate change	0.631	1.586
Mean VIF		1.455

Source: Author's computation (2017)

As shown in the results, out of the independent variables considered in the model (See Table 5.2), seven variables were statistically significant, and they determined the awareness of climate change among the respondents in the study area. The variables included farm size, education, who owns the farm, information received on climate change, source of climate change information, climate change information through extension services and channel of information received on climate change.

Table 5.2: Parameter estimates of the binary logistics regression model on climate change awareness

	Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Years of farming	0.513	0.272	3.558	1	0.059	1.670
	Farm size	-2.354	0.805	8.550	1	0.003*	0.095
	Household size	-0.112	0.526	0.046	1	0.831	0.894
	Household gender	-2.258	1.504	2.254	1	0.133	0.105
	Marital status	1.150	0.620	3.443	1	0.064	3.159
	Education	-1.326	0.507	6.840	1	0.009*	0.265
	Source of income	0.923	1.428	0.417	1	0.518	2.516
	Type of farm	0.042	0.363	0.013	1	0.909	1.043
	Who manages the farm?	-0.173	1.163	0.022	1	0.882	0.841
	Who owns the farm?	2.899	1.030	7.917	1	0.005*	18.164
	Land acquisition	-0.226	0.247	0.839	1	0.360	0.797
	Information receive on climate change	18.809	6.067	9.612	1	0.002*	147421424.61
	Source of climate change information	-2.376	0.928	6.552	1	0.010*	0.093
	Climate change information through extension services	4.912	1.206	16.604	1	0.000*	135.941
	Channel of information received on climate change	-1.788	0.732	5.977	1	0.014**	0.167
	Support received on climate change	-.409	0.258	2.524	1	0.112	0.664
	Constant	-7.763	4.034	3.703	1	0.054	0.000
Step	-2 Log likelihood		Cox & Snell R Square			Nagelkerke R Square	
	60.167[a]		0.322			0.748	

Source: Author's computation (2017)

Note: *and ** Means 1% and 5% Levels of Significant Respectively

5.2.1 Results and discussion

According to Table 5.2, the variable farm size, was strongly associated and statistically significant ($p<0.05$) to climate change awareness with a negative coefficient (-2.354). This implies that the

probability of the household farm size decreased as awareness was made on climate change in the study area with the odd ratio of 1.670. Farming households tend to operate a small farm size as climate change awareness increased. This reason is not far-fetched from the fact that, most small-scale household farmers in the study area were poor and less resourceful, and coping with climate change was a challenge, even if they were aware. Farmers with large farm size mostly have resources and they are likely to have more capacity to try out and invest in climate risk coping strategies (Ali and Erenstein, 2017). Thus, farmers in the study area tend to reduce the amount of land cultivated as an adaptation measure (see Table 4.21) to climate change in other to maximize produce.

In Table 5.2, education was statistically significant ($p<0.05$) with a negative coefficient (-1.326), that is, education decreased the probability of climate change awareness with an odds ratio of 0.265. The implication is that the level of education had a significant difference on the farmers' awareness to climate change. Climate change awareness and level of education enhance informed decision-making and play a significant role in increasing adaptation and mitigation capacities of household farming. This result was supported by Bayard *et al.* (2007), who reported similar results that education significantly, but negatively, affected climate change awareness. Likewise, the studies carried out by Deressa *et al.* (2009), Deressa *et al.* (2010) and Maddison (2006), recorded similar evidence, whereby education of household heads increased the probability of awareness and adaptation to climate change. Mandleni (2011), aligns with the findings of this current research because the researcher also submitted that education significantly affected awareness about climate change.

In Table 5.2, the variable (who owns the farm) was found to be statistically significant ($p<0.05$) to climate change awareness with a positive coefficient (2.899). Who owns the farm increased the probability of awareness of climate change. Majority of the households farming who owned the farms were individual households. This indicates that individual household who owns a farm tends to be more aware of climate change in order to cope and engage in adaptation measures to improve food production and sustain livelihood. This is in consonance with Shultz *et al.* (1997), for the examination indicated that land ownership individually managed, is widely believed to encourage the adaptation.

According to Table 5.2, climate change awareness and the information received are positively associated and increased the probability or likelihood of climate change awareness. The result revealed that information received on climate was statistically significant ($p<0.05$) to climate change. Information on climate change increased awareness on climate change thus enhancing farmers' knowledge on how to adapt to climate change. Most of the farming households in the study area had access to radios, flyers, magazine, the local newspaper, amongst many others which provided information on climate change awareness. Evenly, Deressa *et al.* (2009), reported that information on temperature and rainfall had a significant and positive impact on climate change awareness. Additionally, a research on climate change by Bryan *et al.* (2009), enunciated that information on climate change was found to facilitate climate change awareness and adaptation among the poorest farmers.

Table 5.2 revealed that the source of climate change information is statistically significant ($p< 0.05$) to the determinant of climate change in the study area. Majority of the respondents obtained climate change information from the media such as radio as they did not have access to internet, an indication that information technology remained a challenge. The findings harmonized with Maponya and Mpandeli (2012), and Oduniyi (2014), who also found that most farmers in rural areas did not have access to other sources of information such as internet, magazines. Relatedly, Nwagbara and Nwagbara (2017), enounced that in a research conducted in Abia State, Nigeria, the role of radio stations in building awareness of climate change among crop farmers is vital.

According to Table 5.2, the results of the analysis further showed that extension service was statistically significant ($p<0.05$), with a positive association, and it increased the likelihood or probability of climate change awareness. Extension services provided a vital source of information on climate change as well as agricultural production and management practices. This is not surprising because the investigation evinced that majority of the farming household were already aware of climate change. Various studies in developing countries, including Ethiopia, reported a strong positive relationship between access to information and the adoption behaviour of farmers (Yirga, 2007). The innovation and information obtained by the farmers on production activities are determined by the extension agents; thus, extension contacts are the carrier of change (Idris *et*

al., 2012). IFPRI (2007), also attested to the notion that improving access to extension services for farmers has the potential to significantly increase farmers' awareness of changing climatic conditions.

In Table 5.2, the channel of information received on climate change by the farming households was statistically significant ($p<0.05$), and negatively associated to climate change awareness. This variable decreased the likelihood or the probability of climate change awareness with an odd ratio of 0.167. The channel of information determines climate change awareness and information dissemination, thus, improving adaptation and reducing the risk of climate change while concurrently sustaining households' livelihood. This is supported by Evelyne and Franzel (2015), who divulged that the channel of information plays a complementary role to facilitate the spread of agricultural technologies and improving farmers' capacities. Information channel is more effective and offer a wide-reaching alternative in supporting agricultural innovation (Ssemakula and Mutimba, 2011; Wellard *et al.,* 2013).

5.3 Summary

The chapter presented the results of climate change awareness and its determinants in the study area. Multicollinearity test was carried out, followed by binary logistics regression model. The study established that the majority of the farmers were aware of climate change and its impacts. However, climate change awareness in the study area was influenced by the following factors: farm size, level of education, who owns the farm?, information received on climate change, source of climate change information, climate change information through extension services, channel of information received on climate change and support received on climate change.

CHAPTER SIX
CLIMATE CHANGE ADAPTATION AND THE INFLEUNCING FACTORS AMONG THE FARMERS IN THE STUDY AREA

6.1 Introduction

This chapter examined the factors that influenced climate change adaptation among the respondents in the study area. Various research has been carried out to identify several adaptation strategies which involve taking practical actions to manage risks from climate impacts, protect the environment and build resilience to climate change. Despite the effort, rural farming households are still struggling to effectively incorporate adaptation strategies in their farming activities. Thus, this section seeks to analyze the determinant factors facing the rural farmers to climate change adaptation in the study area.

6.2 Factors that influenced climate change adaptation in the study area

This section details the factors that influenced climate change adaptation in the study area. In order to achieve this, Tobit regression model was employed to analyse factors influencing climate change adaptation in the study area as presented in equation 3.13 of Chapter Three. The dependent variable was determined in a way that different observations regarding climate change adaptation strategies were censored at minimum and maximum. This was achieved by dividing the number of climate change adaptation strategies used by the individual farmers by all the climate change adaptation strategies available in the study area. Thus the value of the dependent variable ranges between zero (0) and one (1). For example, a respondent used 7 (seven) adaptation strategies out of 10 (ten) available adaptation strategies, then, 7 was divided by 10, leading to 0.7. Thus, it means that the respondent used 70% of the available adaptation strategies, 0.7 gives a range which was used as the dependent variable for such respondent. The explanatory variables were generated from PCA which was regressed against the dependable variable. The generated independent variables were used in the Tobit regression.

Table 6.1 shows the test for multicollinearity among the variables. This was carried out with variance inflation factor (VIF), and the mean VIF was 1.422. Multicollinearity was used to remove

the explanatory variables that were correlated after which PCA was employed to identify the factor loadings of the variables. Also, high level of tolerance computed for the variables shows that there was no multicollinearity in the analysis.

Table 6.1: Multicollinearity analysis

Variables	Collinearity Statistics	
	Tolerance	VIF
Number of years in farming	0.578	1.731
Farm size	0.731	1.367
Household size	0.760	1.315
Household gender	0.816	1.225
Household marital status	0.706	1.416
Education level	0.602	1.661
Farming as major income	0.567	1.763
Types of farm	0.787	1.270
Who manages the farm?	0.919	1.088
Who owns the farm?	0.799	1.251
Land acquisition	0.741	1.350
Climate change awareness	0.748	1.337
Source of climate change information	0.707	1.414
Climate change information through extension services	0.723	1.382
Channel of information received on climate change	0.658	1.519
Support received on climate change	0.617	1.620
Adaptation barrier	0.685	1.460
Mean VIF		1.422

Source: Author's computation (2017)

Table 6.2 shows that the first Principal Component (PC) to the fifth PC were retained. The number of PCs retained was achieved using the eigenvalue criterion, also known as the Kaiser criterion, whereby only the PCs in which the eigenvalues ≥ 1 were retained. In the same manner, any PC with an eigenvalue ≤ 1 contained less information than one of the original variables and were not worth retaining. The justification for this criterion was that since each observed variable contributed one unit of variance to the total variance in the data set, any component that demonstrated an eigenvalue ≥ 1 accounted for a greater amount of variance than had been

contributed by one variable. Such a component shows a significant amount of variance worth to be retained. The scree plot as shown in Figure 6.1 revealed the number of PCs that were retained. In the scree plot diagram, eigenvalues were plotted against PC numbers. The eigenvalues were shown on the y-axis while the component numbers were shown on the x-axis. The PCs retained were those ≥ 1, which are on the slope of the graph before the decrease of eigenvalues levels off to the right of the plot. With this criterion, 8 PCs were retained in the analysis of this study.

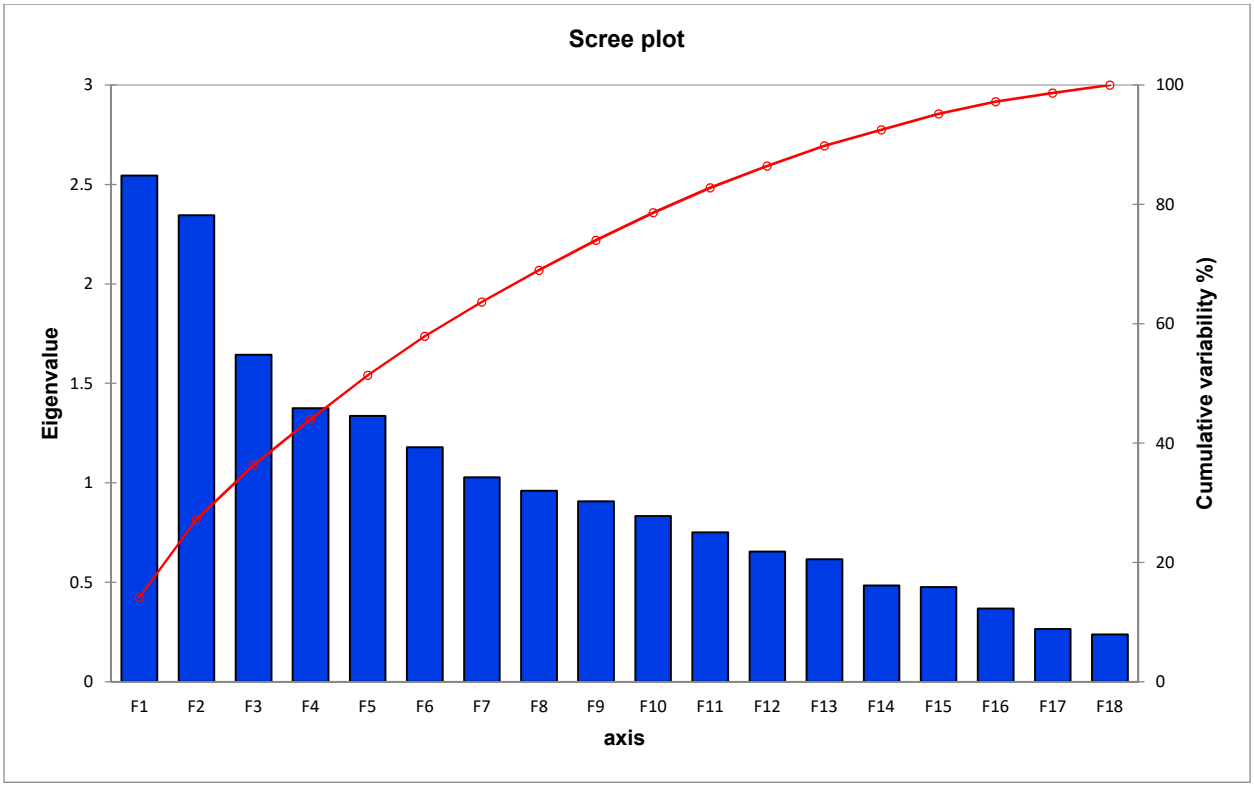

Figure 6.1 Scree Plot of Principal Components and Eigen Values

Source: Author's computation (2017)

6.2.1 Results and discussion

Principal Component 1 (PC_1) contributed to 14.136 percent of the variations with an eigenvalue of 2.544 in the variables included in which the cumulative percentage is 14.136 as reflected in Table 6.2. The (PC_1) is strongly correlated with four of the original variables. This suggests that these four criteria or variables in the principal component vary together. The (PC_1) increases with household age, and marital status, however, on the other hand, it decreases with education and

source of income. This indicates that climate change adaptation is largely influenced by the previous variables mentioned, and this can be represented as follows: $(PC_1) = 0.830X_5 + 0.585X_6 - 0.604X_7 - 0.511X_8$.

Table 6.2: Principal component (PC) retained and percentage of variance explained/Factor analysis

Variable	PC1	PC2	PC3	PC4	PC5
Years of farming (X1)	0.371	-0.470	0.027	-0.495	0.184
Farm size (X2)	0.313	-0.179	-0.423	-0.027	-0.250
Household size (X3)	0.328	-0.201	0.241	-0.039	0.137
Household gender (X4)	0.053	0.236	-0.051	**0.701**	0.214
Household age (X5)	**0.830**	0.065	0.003	0.039	-0.062
Marital status (X6)	**0.585**	0.305	-0.018	0.258	0.287
Education (X7)	**-0.604**	-0.157	-0.221	0.089	-0.055
Source of income (X8)	**-0.511**	-0.296	-0.017	0.430	0.261
Type of Farm (X9)	0.432	-0.144	**0.520**	0.194	-0.242
Who manages the farm (X10)	0.209	0.136	-0.324	-0.197	-0.019
Who owns the farm (X11)	0.156	0.443	-0.329	0.099	-0.007
Land acquisition (X12)	0.252	-0.064	**0.503**	0.372	-0.274
Climate change awareness (X13)	0.029	0.446	0.232	-0.248	0.444
Source of climate change information (X14)	0.149	**0.518**	-0.177	-0.045	**0.520**
Climate information through extension services (X15)	-0.159	**0.641**	0.070	-0.016	-0.149
Channel of information on climate change (X16)	-0.262	0.494	0.418	-0.239	-0.226
Support received on climate change (X17)	-0.258	-0.194	**0.569**	-0.120	0.479
Adaptation barrier (X18)	0.197	**-0.622**	-0.173	0.123	0.337
Eigenvalue	2.544	2.345	1.644	1.375	1.336
Variability (%)	14.136	13.028	9.136	7.636	7.424
Cumulative %	14.136	27.164	36.300	43.936	51.360

Source: Author's computation (2017)

Principal Component 2 (PC_2) as shown in Table 6.2 contributed to 13.028 percent of the variations with an eigenvalue of 2.345 in the variables included in which the cumulative percentage is 27.164. The PC_2 is strongly correlated with three of the original variables. The result shows that the PC_2 increases with source of climate change information and climate information through extension source. However, it decreases with adaptation barrier. This indicates that the variables aforementioned influence climate change adaptation. This can be represented as follows: $(PC_2) = 0.518X_{14} + 0.641X_{15} - 0.622X_{18.}$

According to Table 6.2, Principal Component 3 (PC_3) contributed to 9.136 percent of the variations with an eigenvalue of 1.644 in the variables included in which the cumulative percentage is 36.300 percent. The PC_3 increases with the type of farm, land acquisition and support received on climate change. This suggests that these three variables influence climate change adaptation and can be represented as follows: $(PC_3) = 0.520X_9 + 0.503X_{12} + 0.569X_{17.}$

In Table 6.2, Principal Component 4 (PC_4) contributed to 7.636 percent of the variations with an eigenvalue of 1.375 in the variables included in which the cumulative percentage is 43.936 percent. The PC_4 increases with household gender. This proposes that household gender influence climate change adaptation and it can be represented as follow: $(PC_4) = 0.701X_4$.

Principal Component 5 (PC_5) as revealed in Table 6.2, contributed to 7.424 percent of the variations with an eigenvalue of 1.336 in the variables included in which the cumulative percentage is 51.360. The PC_5 increases with source of climate change information. This suggests that climate change adaptation can be influenced by source of climate change information, thus, it can be represented as follows: $(PC_5) = 0.520X_{14}$.

Table 6.3, revealed that, household farm size is statistically significant ($p<0.05$) and had a negative association. This suggests that the size of the farm had influence on climate change adaptation in the study area. Farmers with small land holdings tend to ignore adaptation measures as a result of low resources; however, farmers with large farm size are likely to have more capacity to try out various adaptation strategies and invest in climate risk coping strategies. The larger the farm size is, the more the adaptation strategies of changing crop cultivars and crop types. This result

maintained a parallel with the findings of Abid *et al.* (2015). The research ascertained that farmers with large farm size try more adaptation options. On the contrary, Mohammed *et al.* (2014), registered a negative result where a large farm size requires more capital to carry out or execute adaptive strategies to climate change. The same result was presented by Acquah (2011), that farm size was negatively significant to climate change adaptation and its effects.

According to Table 6.3, household gender is statistically significant ($p<0.05$) and influences the climate change adaptation. Various researches have revealed that gender is an important and sensitive factor affecting adoption decision among farmers. The involvement of women in agriculture encourages more climate change adaptation because they adopt a very active attitude towards farming activities, like weeding, and many more, particularly where the onus of providing and caring for the family rests on them. The result of Maponya (2012), corresponds with the outcome of the study; the research proved that females are more involved in agriculture practices than men. In the same vein, Stanley Sharaunga *et al.* (2015), asserted that empowering women in smallholder agriculture is very crucial in reducing vulnerability to climate change among rural households. The increasing role that rural women are playing in smallholder agriculture provides an important opportunity to positively impact food production and security in a changing climate (Carvajal-Escobar *et al.,* 2008).

Proportionally, Nhemachena and Hassan (2007), had similar findings, for they found that women are mostly versed in farming activities such as harvesting, weeding, while men are in the city looking for lucrative job opportunities. On account of effective participation in farming, female farmers are prompt to adopt practices that conserve natural resources and its management (Bayard *et al.,* 2007). In addition, Burton *et al.* (1999), emphasized that it is germane to consider the functioning roles of female farmers because they are important in the choice of agricultural practices to adopt especially in regard to conservation. Still aligning with this current study, Anim (1999), verified that rural women are characterized with more farming experience, as such when given available useful information, it can help improve farming practices.

In contrast, male farmers are more likely to perceive a change in the climatic condition unlike female farmers because male-headed households have a higher probability of acquiring

information than female-headed households. Nevertheless, female farmers tend to use adaptation measures to climate change than male farmers, and vice versa, because women are more involved and do much of farm work in other to gather food for the household. This finding recorded a match with the investigations of Asfaw and Admassie (2004), Tenge and Hella (2004); they noted that male-headed households were more likely to perceive changes in the surrounding than female-headed households.

Table 6.3: Parameter estimates of the Tobit regression analysis on factors that influence Climate change adaptation

Variables	Coefficient	Std. Error	z- Statistic	Pr(>|z|)
Years of farming (X_1)	0.006116	0.003868	1.581138	0.1138
Farm size (X_2)	-0.013340	0.004865	-2.742015	0.0061
Household size (X_3)	-0.005277	0.005735	-0.920130	0.3575
Household gender (X_4)	-0.062083	0.016218	-3.827976	0.0001
Marital status (X_5)	0.010947	0.006693	1.635506	0.1019
Education (X_6)	0.005051	0.005117	0.987128	0.3236
Source of income (X_7)	-0.017227	0.015601	-1.104226	0.2695
Type of farm (X_8)	-0.009591	0.004362	-2.198753	0.0279
Who manage the farm (X_9)	0.003761	0.026335	0.142799	0.8864
Who owns the farm (X_{10})	-0.022814	0.011036	-2.067288	0.0387
Land acquisition (X_{11})	0.009078	0.003044	2.982234	0.0029
Climate change awareness (X_{12})	0.098297	0.066811	1.471266	0.1412
Source of climate change information (X_{13})	0.022988	0.007113	3.232000	0.0012
Climate information through extension services (X_{14})	0.013465	0.014691	0.916559	0.3594
Channel of information on climate change (X_{15})	0.007942	0.005393	1.472588	0.1409
Support received on climate change (X_{16})	-0.005196	0.002948	-1.762625	0.0780
Adaptation barrier (X_{17})	-0.190419	0.006259	-30.42514	0.0000
C	0.203205	0.277651	0.731872	0.4642
Error Distribution				
SCALE:C (19)	0.099657	0.003788	26.30651	0.0000
Mean dependent var	1.057803	S.D. dependent var	0.233709	
S.E. of regression	0.102511	Akaike info criterion	-1.664344	
Sum squared resid	3.436285	Schwarz criterion	-1.453124	
Log likelihood	306.9315	Hannan-Quinn criter.	-1.580235	
Avg. log likelihood	0.887085			

Wald Test Equation:

Test Statistic	Value	df	Probability
F-statistic	91.26040	(17, 327)	0.0000
Chi-square	1551.427	17	0.0000

Source: Author's computation (2017)

Note: $p < 0.05$; $p < 0.01$ at 5% and 1% level of significant respectively.

In Table 6.3, the type of farm a household head is engaged in has influence on climate change adaptation. The type of farm in this regard includes individual farm, family farm, community and tribal farm which is statistically significant ($p<0.05$) to climate change adaptation. This denotes that individual farms adopt natural resources management and conservation practices better compared to tribal or community farm type as individual can manage information based on his or her household resources and needs.

By the same token, the variable, who owns the farm as shown in Table 6.3, is statistically significant ($p<0.05$) and influence climate change adaptation strategies. The variable who owns the farm in this study was classified into individual, family members, farmer groups and cooperate farm. This result implies that the knowledge and experience of the farm owner determines the adoption of natural resources management and conservation practices to use. Similarly, several researches (Maddison, 2007; Wozniak, 1984; Noor, 1981; Omolola, 2005) articulated that farmers who had gone through training or teaching are presumed to have developed more skills and understanding of climate change and adaptation options to deal with the challenges of climate. Land ownership is likely to influence adoption if the innovation requires investments tied to land (Maponya, 2012).

Households have the tendency to adopt adaptation strategies better under the influence of groups. The reason for this inclination is because farmer groups create opportunity for individual household heads to learn and share ideas on various indigenous knowledge and adaptation options to cope in the face of climate change events. Shultz *et al*. (1997), reported that land ownership individually managed, is generally assumed to improve the adoption of technologies connected to physical assets such as land.

Land is a fundamental factor of production. According to Table 6.3, the method of acquiring land or farm by the farmers is statistically significant ($p<0.05$) and influence climate change adaptation in the study area. Various methods of land acquisition as identified in the study area, which include: land redistribution for agricultural development (LRAD), PLAS, land affair, hire, inheritance and own finance. This result signifies that adaptation strategies are linked to land acquisition method.

Farmers, who buy land, hire or through land affair are inclined to adopt adaptation strategies more as they need to produce much in other to pay and make profit to sustain livelihood.

The sources of information received on climate change influence adaptation strategies. Table 6.3 shows that source of information is statistically significant ($p<0.05$) where majority of the households in the study area obtained information through the radio. The source of information influence climate change adaptation because information from non-reputable source might not be the reliable information needed to adapt in order to transform or increase food productivity, and besides, different information target different environment and farming systems. In addition, the source where information is being received determines the effectiveness and farmers' adoption. According to Akinnagbe *et al.* (2015), it was reported that crop farmers received their information from sources which could not be unconnected with their level of interaction in the communities. Thus, it is palpable that extension officers play a significant role in the dissemination of the information needed by farmers (Gabriel *et al.*, 2013).

According to Table 6.3, the support received by the farmers was found to be statistically significant ($p<0.05$). The support received includes: formal credit, insurance, farmer to farmer extension, relatives, subsidies. Adaptation to climate change becomes easier when farmers receive support on climate change. The inability of the farmers to get the necessary support and resources could hinder the farmers from adapting to climate change. Relatedly, Kandlinkar and Risbey (2000), opined that most farmers in Africa are operating under resource limitation which prevents adaptation measures. Ziervogel and Polly (2010), equally maintained that institutional support for climate change adaptation is needed for rural farmers to adapt to climate change consequence and events.

The examination in Table 6.3, also showed that adaptation barrier is statistically significant ($p<0.05$) and influence climate change adaptation in the study area. It was discovered that barriers to adaptation restrict people's ability to address the negative impacts of climate change. Examples of adaptation barrier in the study area as shown in Table 6.1, are lack of knowledge and education, lack of structural and infrastructural resources, lack of capital resources and inaccessibility to extension officers. Adaptation barriers prevent farmers from adopting various strategies and

practices to cope with the impact of climate change variability and events. Farmers need resources and information to be able to adapt without which farm productivity is affected. This finding is duplicated in the research carried out by Smit and Skinner (2002), the study confirmed that adaptation barrier is influenced by financial capital. Obviously, lack of financial capital prevents the adoption of improved seeds and technologies.

Helms (2006), revealed that budget constraints could also pose a barrier when adaptation measures involved high upfront cost. Those with limited financial capital focused on short-term gain rather than on the potential long-term benefits of reduced vulnerability. According to Cruz *et al.* (2007), inadequate information and understanding on the impacts of climate change could impede and serve as a constraint to climate change adaptation (Jones and Boyd, 2011).

6.3 Summary

The chapter presented the results of factors that influence climate change adaptation in the study area. Firstly, Principal component analysis (PCA), was employed to reduce the numerous variables after which test of multicollinearity was performed. Lastly, the Tobit regression model was carried out to examine the factors that determine climate change adaptation among the rural household farmers. Conclusively, the identified factors were: farm size, household gender, type of farms, who owns the farm, land acquisition, source of climate change information, support received on climate change, and adaptation barrier.

CHAPTER SEVEN
THE EFFECT OF CLIMATE CHANGE ON FARMERS' LIVELIHOOD CAPITALS

7.1 Introduction

This chapter discusses the results regarding the effect of climate change on farmers' livelihood capitals in the study area. The financial capital livelihood is essentially the focus of this study, among other aspects of capital livelihood. The section expands on the endogenous variables along with the instrumental variables which were regressed against the dependent variables. Additionally, the effect of climate change on financial capital livelihood parameters was identified.

7.2 Estimates of Two-stage least-squares regression model

The two-stage least squares method is used to handle model with endogenous explanatory variables in a linear regression framework. Following the lead of the research conducted by Adelakan and Omotayo (2016), Two-Stage Least-Squares Regression model was employed where the dependent variable was regressed against the independent variables (endogenous variables) and instrumental variables. The dependent variable for this objective was determined through an in-depth examination to affirm respondents' understanding of the effect of climate change on their livelihood.

This section explained the test for multicollinearity among the variables. The results show the mean variance inflation factor (VIF) of 1.057. As shown in Table 7.1, it was revealed that there was no multicollinearity among the variables. The variables were endogenous and were correlated with the error term in the regression model. However, instrumental variables were introduced which were uncorrelated with the error term to estimate the model parameters. These instrumental variables are correlated to the endogenous variables but not with the error term of the model. Instrumental variables used in the regression framework were: income, landed property and assets.

Table 7.1: Multicollinearity test of variables

Variables	Collinearity Statistics	
	Tolerance	VIF
Climate change awareness (X_1)	0.991	1.009
Low Farm income (X_2)	0.991	1.009
Low profits (X_3)	0.986	1.014
Personal savings (X_4)	0.869	1.151
Cooperative finance (X_5)	0.870	1.149
Loan repayment (X_6)	0.988	1.012
Mean VIF		1.057

Source: Author's computation (2017).

7.2.1 Results and discussion

The relationship between climate change and financial livelihood capital is illustrated in Table 7.2. Climate change awareness (an indicator in the model) was found to be positive (0.758550) and statistically significant ($p<0.05$), which implies that awareness on climate change had influence and could link farmers' financial livelihood capital to climate change. Climate change in the study area had a severe impact on the maize yield and farm productivity which reflected to be one of the most disruptive weapon that threatened financial livelihood capital. However, awareness on climate change, being established as a significant variable from the relationship or effect of climate change and financial livelihood capital in the result (See Table 7.2), could trigger rural household farmers to embrace effective adaptation measures on climate change to increase farm production, thus, boost financial livelihood capital. The study conducted by Quiroga and Suárez (2015), is in consistent with the findings of this study where awareness on climate change could reduce the negative impact of climate change on livelihood (income distribution) in the Mediterranean, Spain.

Table 7.2: Two-stage least square regression analysis result of the effect of climate change on Financial livelihood capital

Variables	Coefficient	Std. Error	t-Statistic	Pr(>|z|)
Climate change awareness (X_1)	0.758550	0.240020	3.160357	0.0017
Low farm income (X_2)	-0.039287	0.048254	-0.814173	0.4161
Low profits (X_3)	-0.099369	0.050275	-1.976516	0.0489
Personal savings (X_4)	-0.054699	0.047629	-1.148442	0.2516
Cooperative finance (X_5)	0.116046	0.051730	2.243292	0.0255
Loan repayment (X_6)	0.050383	0.053950	0.933889	0.3510
C	0.488780	0.319665	1.529040	0.1272

R-squared	0.062151	Mean dependent var	1.225434
Adjusted R-squared	0.037030	S.D. dependent var	0.418473
S.E. of regression	0.410652	Sum squared resid	56.66125
F-statistic	2.474074	Durbin-Watson stat	2.550096
Prob(F-statistic)	0.009594	Second-Stage SSR	56.66125

Source: Author's computation (2017)

Note: $p < 0.05$; $p < 0.01$ at 5% and 1% level of significant respectively

The relationship or effect of climate change on financial capital livelihood is reflected in low profits. Consequentially, Table 7.2 shows that low profit was negative (-0.099369) and statistically significant ($p<0.05$). Low profit (livelihood indicator) relates to climate change effect on capital livelihood, which implies, climate change had a negative impact on livelihood resulting into low profit. Rural household farmers tend to experience little or no profit because of low yield and poor farm productivity caused by the impact of climate variability. Maize enterprise (livelihood capital) in the study area had a negative relationship with climate change resulted into low profit. The result is not surprising, as most of the farmers in the study area claimed they received little or no profit but were able to recover from the shocks through remittance, grants from the government and other means that were non-farm activities. Low crop yields are a stressor that acts on farmer's financial capital, hence resulting in low profit (Hesselberg and Yaro, 2006; Codjoe and Owusu, 2011).

According to Yaro (2006), the same report was made among rural household farmers in northern Ghana, for it was discovered that climate change contributed to low profit.

Lastly, the relationship between climate change and financial livelihood capital in Table 7.2 is indicated on cooperative finance (livelihood indicator). The variable was statistically significant ($p<0.05$), and its coefficient had a positive relationship (0.116046) to climate change. The implication is that cooperative finance positively impacted the effect of climate change on livelihood. The significance of this variable is that it contributed and reduced the effect or shock of climate change on livelihood. This outcome is expected because cooperative finance act as a financial institution that is owned and operated by its members, and one of its responsibilities is to assist farmers' group to minimize the effect of climate change. Being part of cooperative finance, it was revealed by the farmers that organization such as mines plough, positively impact the rural community by ploughing back or funding to the farmers in the study area for the running of the farming activities through long-term and short-term financial planning and the implementation of farming projects.

In agreement, Smit and Skinner (2002), disclosed that, corporate finance provides cooperative programmes (agricultural subsidy and support) which are utilitarian responses to the economic risks associated with climate change; asides, these programmes have the potential to influence farm-level risk management strategies. They can equally decrease the risk of climate-related income loss and spread exposure to climate-related risks publicly. All of these programmes greatly influence farm-level production and management strategies by transferring risk in agriculture (Smit *et al.,* 2000).

7.3 Summary

The chapter presented the results of the effect of climate change on livelihood (financial) capitals among the rural households in the study area. The study identified the relationship and effects of climate change on financial capital livelihood to be: climate change awareness, low profits, and cooperative finance.

CHAPTER EIGHT
SUMMARY, CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

This chapter presents the synopsis of the study. It covered the introduction, literature review on the implication of climate change on livelihood and climate change adaptation on the global level, in Africa, and in South Africa. The research methodology used to achieve the aim of the study was explained. Furthermore, the chapter also summarized the key research findings according to the set-out objectives aforementioned at the beginning of the study. The chapter also includes conclusion and policy recommendation.

8.2 Research findings and summary

This study is intended to contribute to the body of knowledge on the implication of climate change on livelihood and adaptation of small and emerging maize farmers in North West province of South Africa. The study was conducted in Ngaka Modiri Molema District Municipality in the North West Province of South Africa. The objectives of the study as outlined in Chapter one were to: (i) Analyse the socio-economic characteristics of the smallholder and emerging farmers/respondents of the study. (ii) Identify climate change adaptation strategies among in the study area. (iii) Determine the awareness of climate change among the respondents. (iv) Identify factors that influence climate change adaptation among the respondents in the study area.
(v) Analyse the effect of climate change on respondents' livelihood in the study area. Hypothesis, problem statements, and motivation of the study were also mentioned.

In order to achieve the purpose of this study, an ample review on the concept of livelihood, rural livelihood and agriculture, sustainable livelihood framework, sustainable livelihood framework analysis, maize farming and sustainable livelihood were provided. The literature reviews also focused on the understanding of climate change, impact of climate change on livelihood, impact of climate change on agricultural production, maize production and livelihood, climate change adaptation and its strategies were identified.

The third chapter expounded on the characteristics of the study area, the method of data collection through questionnaires, involving interviews with 346 small and emerging maize farmers. The research instrument, population, sampling procedure and sample size, as well as the analytical techniques methods were discussed. The research findings were categorized according to the objectives of the study. The objectives of the study were intended to meet the current problems facing the rural farming households in relation to the impact of climate change on livelihood and adaptation strategies. Subsequently, the findings are summarized below:

8.2.1 Climate change adaptation strategies

As aforementioned in Chapter Four, descriptive analysis explained the distribution of the respondents in the study area according to socio-economic characteristics, climate change related information, the adaptation strategies and the implication of climate change on livelihood. The research results of the sampled data unveiled the different adaptation strategies used by the small and emerging maize farmers in the study area. They were minimum or zero tillage, crop diversification, planting of different crops, planting of tolerant maize seeds, change to drought tolerance crops, crop rotation, changing the planting dates, planting in different areas, reduced cultivated land, ripping deeper and ploughing every year, prayers, planting of maturity cultivars, shortening of the growing periods, improved land management and change of production practices. However, minimum tillage was mostly used which constitute about 37.3 percent of the respondents.

8.2.2 Climate change awareness

The findings in the fifth chapter of the study revealed that majority of the respondents in the study area were aware of climate change. Furthermore, the examination showed that out of the independent variables considered in the model (See Table 5.2), seven variables were statistically significant ($p<0.05$), and consequently they determined the awareness of climate change among the respondents in the study area. The determinant factors were farm size, level of education, farm ownership, information received on climate change, source of climate change information, climate change information through extension services and channel of information received on climate change.

8.2.3 Factors that influenced climate change adaptation

Principal component analysis and Tobit regression model were used to determine factors that influenced climate change adaptation. The explanatory variables were generated from PCA and regressed against the dependable variable. The generated independent variables were used in the Tobit regression analysis. The research findings itemized determinants factors that influenced climate change adaptation in the study area. The list is as follows: farm size, household gender, type of farms, who owns the farm? land acquisition, source of climate change information, support received on climate change, and adaptation barrier.

8.2.4 Effect of climate change on farmers' livelihood capitals

The central aim of this research study was to determine the effect of climate change on livelihood capitals among the farming households in the study. Two-Stage Least Squares Regression model was employed to achieve this, where the dependent variable was regressed against the independent variables (endogenous variables) and instrumental variables. The study identified the effect and the relationship of climate change on financial capital livelihood to be: climate change awareness, low profits and cooperative finance.

8.3 Conclusion

The study was set out to evaluate the implication of climate change on livelihood and adaptation of small and emerging maize farmers in the study area. Several studies in many places have been conducted to understand climate change awareness and adaptation strategies among the farmers. Only a few empirical works exist which investigate the effect of climate change on livelihood (financial livelihood capitals) among the rural farming household. In order to attain the research objectives, a holistic approach was used to establish the set out objectives. This study highlights the determinants of climate change awareness and adaptation among smallholder rural households in the study area does not only entail scientific knowledge but also community involvement and development of solutions using local approach and socio-economic characteristics of the rural household to act collectively (denoted as social capital) in the face of the threats posed by climate change. Also, the effect of climate change on financial livelihood capital were stated in the findings above.

8.4 Recommendations

There is a number of recommendations arising from the research study which covers the climate change awareness, adaptation measure, and livelihood capitals. These recommendations could be considered by the Department of Agriculture, the farmers and other key stakeholders who are involved in climate change policy and programme. The following recommendations are suggested:

(1) Education attainment is a key significant variable as it was emphasized in this study. Education is important and plays a key role to climate change awareness. It is therefore suggested that education in the form of training and workshop should be provided through extension agents in order to enhance farmer's knowledge and skills on climate change awareness.

(2) The size of the farm contributed to the climate change adaptation and awareness. The study shows that farmers occupy small land hectares for their farming enterprise in order to adapt. However, for agricultural sustainability among the rural households, there is a need for an increase in the farm size for crop risk management and diversification. Thus, the study suggests that the government should increase land capacity among the rural household farmers, supply the necessary resources needed such as infrastructural and structural resources, which could incentivize farmers to coop in the face of climate change and advance in more sustainable farming practices in the study area.

(3) Gender is a significant variable as highlighted in the study. The role of women in agriculture is vital to climate change adaptation, as female farmers are important in the choice of agricultural practices to adopt especially in regard to conservation. As stated in the study, rural women are characterized with more farming experience, as such when given available useful information, it can help improve farming practices. It is therefore recommended that the government should encourage the involvement or participation of women in agriculture by implementing policies that accommodate women in agriculture.

(4) Extension service is significant to climate change awareness determinant in the study. This plays an important role in disseminating adequate information to the farmers. It is recommended that extension officers should design and introduce a strategy that fosters and manages an effective

extension service among the farmers in the rural communities so as to improve the information on climate change awareness and adaptation strategies. Extension officers should provide ample information on climate change and environmental issues as well as adaptation measures, thereby improving farmers' skills to adapt to climate change.

(5) The support received on climate change is significant to the study. Thus, it is recommended that government should put in place agricultural disaster insurance system or policy to compensate for losses. In the same vein, provision of government subsidies should be encouraged and distributed uniformly among the rural farming households.

(6) Rural household farmers receive support on climate change through farmers' group and association as stated in the study. It is suggested that networking among farmers should be improved as most of the information shared is through farmer to farmer groups. The department of agriculture and the extension officer should organize regular group meetings with the farmers to strengthen farmers' cooperation, farmers' association, group demonstration, as this creates a forum to support each other on agricultural related issues.

(7) The study reveals that source of climate change information is important to climate change awareness and adaptation. The complexity of climate change, demands that a holistic understanding of the causes and effects of climate change should be shared among the rural farmers. It is, therefore, suggested that information on climate change impact and various adaptation measures should be translated from a scientific point of view to a simple language that the farmers can understand. In addition, different sources of information on a platform that the farmers can understand should be made available.

(8) The government should assist the cooperate finance through a policy that caters and provides resources needed in order for rural households to farming sustainably and improve their livelihood.

(9) The study identify different adaptation strategies in the study area, however, it is therefore recommended that knowledge such as crop diversification, planting different crops, change to drought-tolerant crops, changing the planting dates, planting in different areas, prayers, planting

of early maturity cultivars, shortening the growing period, improved land management and change of production practices as mentioned by the farmers should be improved in order to cope in the face of climate change.

Other suggestions include:

(10) Use of indigenous knowledge to curb the negative effects of climate change on livelihood and adaptation should be promoted among the farmers. This should not be eschewed, rather it should be inculcated and made to function as a complement to the new scientific method.

(11) The most adaptation strategies used in the study area was zero tillage and planting of different crops. These two strategies are close to conservation agriculture. Thus, it is suggested that conservation agriculture should be encouraged in the study area. This method is a good agricultural practice that is environmentally friendly that increases yields, enough for small and emerging maize farmers to produce more to sustain livelihood in the midst of climate variability. It involves three principles, which are: no or little tillage (minimal soil disturbance) mulching (soil cover) and crop rotation. These three principles can increase agricultural productivity and enhance good soil management. However, the researcher suggested the following cover crops and materials be used for mulching in a maize farming under conservation practice: jack beans, lablab, mucuna pruriens, pigeon pea, cowpeas, common vetch, lima bean, sunn hemp.

(12) Climate-smart agriculture is also suggested in the study area. This is agricultural techniques or strategies which can be used to curb the challenge of reduced maize yields in the midst of climate change problem and events. CSA has three objectives: to sustainably increase agricultural productivity and incomes (improve livelihood), adapting and building resilience to climate change (adaptation measures) and lastly, reducing greenhouse gas emissions (mitigation strategies). Climate-smart agriculture techniques suggested for small and emerging maize farmers in the study area involve practical techniques such as intercropping, agroforestry and improved water management, management of soil organic carbon through improved nitrogen fertilizer or organic manure, low carbon emission agriculture, environmental agricultural practices and replacement of fossil fuel use.

(13) Introduction of drought and heat tolerant seeds should be encouraged in the study area. This can help to give ample yield, generate income and improve financial capital livelihood. In the cause of this study, two different drought and heat tolerant maize seed lines were obtained from CIMMYT by the researcher. The lines were planted in a severe drought environment and still produced a successful good yield.

(14) Additionally farmer mobilization and involvement is important in developing solutions using local approach and socio-economic characteristics of the households affected in the study area to act collectively in the face of the threats posed by climate change. In an attempt to support and promote climate change awareness, households' adaptation measures to climate change, and develop sustainable strategies that will be culturally accepted by rural households farmers and communities in the study area, considerable attention should be paid to understanding the socio-economic characteristics of the rural households, information on climate change (sources and channels) and support received on climate change.

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APPENDIX A: QUESTIONNAIRE

IMPLICATION OF CLIMATE CHANGE ON LIVELIHOOD AND ADAPTATION OF SMALL AND EMERGING MAIZE FARMERS IN THE NORTH WEST PROVINCE OF SOUTH AFRICA.

Date of interview:
Number:
Area

District Municipality	
Local Municipality	
Number of Years Farming in the area	
Size of the farm (ha)	

A.1 COMPOSITION AND HOUSEHOLD CHARACTERSITICS

Size of household	Gender of head of household	Age of head of household (years)	What is marital status of the household head?	Education level	Is farming your major source of income?
1-3…….....1 4-6…….....2 7-9…….....3 10-12...…..4 13-15…....5	Male…….1 Female….2	18-30……..1 31-40……..2 41-50……..3 51-60……..4 61-70……..5 71-80……..6	Single…..……...1 Married……2 Divorced……...3 Widowed……..4 Separated...…...5	Pre-School……...….1 Substandard A & B …..2 Substandard 1 – 5.....….3 Standard 6 – 10....……4 Higher Education.....5 None.....……...6	Yes……..1 No……2

A.2 LAND CHARACTERISTICS

1. Type of Farm

Individual Farm	
Family Farm	
Community Farm	
Corporation/ Company Farm	
Tribal Farm	
Other (please specify)	

2. Who manages the farm?

Individual	
Family Members	
Farmers Group	
Corporation/ Company Farm	
Trust	
Other (specify)	

3. Who owns the farm?

Individual	
Family Members	
Farmers Group	
Corporation/ Company Farm	
Trust	
Other (specify)	

4. If you own the farm how did you acquire it?

Own Finance	
Bond	
LRAD	
PLAS	
Restitution	
Inheritance	
Other , specify (Land Affairs)	
Land Hiring	

B.1 CLIMATE CHANGE RELATED ISSUES

1. **Are you aware of climate change?**

Yes	
No	

2. **Is there any awareness been made in your area on climate change?**

Yes	
No	

3. **Do you perceive climate change?**

Yes	
No	

4. **What perceptions do you have on long-term temperature changes?**

Increased temperature	
Decreased temperature	
Other changes	
No change	
Other (specify)	

5. **What perceptions do you have on long-term rainfall changes?**

Increased rainfall	
Decreased rainfall	
Changes timing of rains	
No changes	
Other (specify)	

6. **Have you ever experience the following lately?**

Frequency of droughts	
Abnormal Wind	
Floods	
Frost	
Cold	
All of the Above	

7. Do you receive information on climate change?

Yes	
No	

8. What is the source of information on climate change?

Flyers	
Magazines	
Radio	
Local Newspapers	
Internet	
Extension Officer	
None	

9. Do you receive information on climate change through extension services?

Yes	
No	

10. Through what channel did you receive information on climate change?

Formal Extension	
Farmer to Farmer	
Family support	
Neighbours	
Municipal Office	
Other (specify)	
None	

11. What kind of support do you receive for climate change impacts?

Formal credit	
Insurance	
Farmer to Farmer extension	
Relatives	
Subsidies	
Other (specify)	
None	

B.2 CLIMATE CHANGE AND CROP FOOD

1. Have you planted maize before?

Yes	
No	

2. Are you still planting maize?

Yes	
No	

2. Reasons for not planting?

Drought	
No Profit	
No Extension support	
No Resources	
Lack Of Skill	
Am still Planting	

4. Has climate change affected your crops?

Yes	
No	

5. To what extent has climate change affected your crops?

Very Bad	
Bad	
Slightly affected	
Not affected	
Other (specify)	

6. What impacts has climate change had on agricultural production?

Reducing fertility of land	
Reduced crop yields	
Increased crops diseases	
All of the above	

7. Has climate change affected your food availability?

Yes	
No	

8. What impacts has climate change had on food security?

Scarcity of food	
Increased food prices	
Lack of local markets	
All of the Above	

9. Are you food secured as a result of climatic condition in your area?

Yes	
No	

B.3 CLIMATE CHANGE AND LIVELIHOOD

1. Which livelihood capitals has Climate Change affected the most?

Human Capital Livelihood	
Natural Capital Livelihood	
Social Capital Livelihood	
Financial Capital Livelihood	
Physical Capital Livelihood	

2. What impacts has climate change had on your livelihood?

Increased socio- economic problems	
Low income	
Increased unemployment	
Reduced cultivated lands	
Reduced cultivated practices	
All of the above	
Not Affected	

3. To what extent has climate change impacted your livelihood?

Low	
High	
Severe	

C.1 ADAPTATION MEASURES

1. **Did you adapt to climate change**

Yes	
No	

2. **What are your perceived adaptations options?**

Plant Different crops	
Plant different varieties	
Crop diversification	
Use different planting dates	
Shorten length of growing period	
Move to different site	
Change amount of land	
Change crops to livestock	
Change from farming to non-farming	
Increase irrigation	
Change use of chemicals , fertilizers and pesticides	
Increase water conservation	
Soil conservation	
Use Insurance	
Use subsidies	
Prayer	
Other adaptation	
No adaptation	

3. **What prevent you from perceiving the adaptations options?**

Lack of Information	
Lack of Education and Knowledge	
I do not perceive or aware of climate change	
Lack of resources to adapt	

4. **What would you consider the most important message in a joint campaign on climate change adaptation?**

5. **What could you do yourself to pass these messages to others and how?**

D.1 WEALTH INDEX

1. **Do you have any landed property?**

Yes	
No	

2. **Do you have transport as a wealth index?**

Yes	
No	

3. **Do you have sustainable income?**

Yes	
No	

4. **Do you have livestock as a wealth index?**

Yes	
No	

5. **Do you have living building or structure for living?**

Yes	
No	

6. **Do you have access to basic necessity such as sanitation facilities?**

Yes	
No	

E.1 FINANCIAL LIVELIHOOD INDICATORS

1. **Has climate change affected your farm income?**

Yes	
No	

2. Has climate change affected your loan repayment?

Yes	
No	

3. Has climate change affected your credit accessibility?

Yes	
No	

4. Has climate change affected your cooperative finance accessibility?

Yes	
No	

5. Has climate change affected your credit accessibility?

Yes	
No	

6. Has climate change affected your money lenders accessibility?

Yes	
No	

7. Has climate change affected your personal savings?

Yes	
No	

8. Has climate change affected your access to government subsidies?

Yes	
No	

9. Has climate change affected your access to financial institution?

Yes	
No	

10. Has climate change affected your employments or job?

Yes	
No	

11. Has climate change contributed to poverty?

Yes	
No	

12. Has climate change affected your food production?

Yes	
No	

13. Has climate change affected your profits?

Yes	
No	

****

Compiled by: Samuel Oduniyi. University of South Africa, Florida

APPENDIX B: CONSENT FORM

CONSENT FORM

Title of the Research Project:

IMPLICATION OF CLIMATE CHANGE ON LIVELIHOOD AND ADAPTATION OF SMALL AND EMERGING MAIZE FARMERS IN NORTH WEST PROVINCE OF SOUTH AFRICA.

Dear Mr/Mrs/Miss/Ms _____ Date……

NATURE AND PURPOSE OF THE STUDY

i. Determine farmers' perception on climate change
ii. Identify and analyze adaptation strategies used by the maize farmers in the province.
iii. Assess mitigation strategies in the study area.
iv. Determine the impact of climate change on livelihood capitals among the maize farmers in the study area.
v. Analyze farmers' prioritization of determinants of cultivation in the past and present.
vi. Analyze the socio-economic determinants of the farmers' perception on climate change impact on their maize production.
vii. Recommend plausible policy interventions that match farmers' perceptions, adaptation strategies and coping mechanisms.

RESEARCH PROCESS

1. The study requires your participation in filling of a short and brief questionnaire on the implication of climate change on livelihood and adaptation of small and emerging maize farmers in North West Province of South Africa.
2. The study will be conducted in Bojanala and Ngaka Modiri Molema District Municipality, North West Province of South Africa. The research will be extended to the five local municipalities under the District. The choice of these purposeful sampling is to ensure that no detail within the reach of the researcher is left out. Secondary sources, information and data will also be used especially in the case of social protection. These will include: journals, internet, local and international newspapers.
3. Basic related information to climate and farming will be required from you such as size of farm, climate change and awareness levels, adaption measure, livelihood indicator.
4. Respondents may be representative of any ethnic group, age or gender.
5. The questionnaire offers you the opportunity to express your opinion on climate change and its implication on your livelihood.
6. Frequency distribution, descriptive statistics, logistic regression model, Tobit regression, Two- Stage least square regression would be used to analyse data.
7. Recommend plausible policy interventions for the framers

NOTIFICATION THAT PHOTOGRAPHIC MATERIAL, TAPE RECORDINGS, ETC WILL BE REQUIRED CONFIDENTIALITY: Information that you will provide to me will not be disclosed to the third person.

WITHDRAWAL CLAUSE: I understand that my participation is voluntary and that I may withdraw from the research at any time, without giving any reason.

POTENTIAL BENEFITS OF THE STUDY

It is hoped that the findings of this study will be a useful contribution for South Africa and other developing countries faced with the challenge of climate change and its impact on livelihood. Specifically, it will help in the areas of adaptation to climate change, mitigation or coping strategies, level of awareness, also to improve food security. It is hoped that it will help them to increase their food production.

INFORMATION (contact information of your supervisor)

B. Mandleni Dr, Block B, Room 333, Florida, Tel: 011 471 2252, Fax: 0865904563
e-mail: mandlb@unisa.ac.za

CONSENT

I, the undersigned, ……..… (Full name) have read the above information relating to the project and have also heard the verbal version, and declare that I understand it. I have been afforded the opportunity to discuss relevant aspects of the project with the project leader, and hereby declare that I agree voluntarily to participate in the project.

I indemnify the university and any employee or student of the university against any liability that I may incur during the course of the project.

I further undertake to make no claim against the university in respect of damages to my person or reputation that may be incurred as a result of the project/trial or through the fault of other participants, unless resulting from negligence on the part of the university, its employees or students.

I have received a signed copy of this consent form.

Signature of participant.....

Signed at …… …..…… on …….....

WITNESSES

1 .....

2 .....

APPENDIX C: UNISA ETHICS APPLICATION OUTCOME

UNISA university of south africa

CAES RESEARCH ETHICS REVIEW COMMITTEE

Date: 06/11/2015

Ref #: **2015/CAES/105**
Name of applicant: **Mr OS Oduniyi**
Student #: **48099449**

Dear Mr Oduniyi,

Decision: Ethics Approval

Proposal: Implication of climate change on livelihood, adaptation and mitigation strategies among small and emerging maize farmers in North West Province of South Africa

Supervisor: Dr B Nkonki-Mandleni

Qualification: Postgraduate degree

Thank you for the application for research ethics clearance by the CAES Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the project, **subject to submission of permission letters from the local traditional leaders.**

Please note point 4 below for further action.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the CAES Research Ethics Review Committee on 05 November 2015.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the CAES Research Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
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www.unisa.ac.za

3) *The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.*
4) *The targeted farmers are more likely to fall under the authorisation of local traditional leaders than the Bojanala Platinum District Municipality. The researcher must establish whether there are traditional leaders in the area and if so, must approach these local leaders for permission to do the research in their jurisdiction, and get their assistance with introduction to the farmers. Once obtained, the permission from the local leaders must be submitted to the Committee.*

Note:
The reference number [top right corner of this communiqué] should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the CAES RERC.

Kind regards,

Signature
CAES RERC Chair: Prof EL Kempen

Signature
CAES Executive Dean: Prof MJ Linington

please note paragraph 4

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APPENDIX D: PERMISSION LETTERS

Office of the Municipal Manager

Bojanala Platinum
District Municipality

21 October 2015

Mr. OS Oduniyi

University of South Africa

Faculty of Environmental Science

Dear Sir/Madam

RE: **REQUEST TO CONDUCT RESEARCH AT BOJANALA PLATINUM DISTRICT MUNICIPALITY**

Your letter dated 15th October 2015, regarding the above matter refers.

You are most welcome to conduct research within the Bojanala District as requested.

You are however requested to liaise directly with the Mayor and or municipal manager of the specific local municipality should your research require you to visit any of the constituent municipalities within the district.

Good luck with your research. It will be appreciated if, at the conclusion of your research, your findings be made available to BPDM as a matter of interest.

Further, contact Director Health & Environmental Services for more information on 014 523 5000.

Yours faithfully

Innocent Sirovha(Mr)

Municipal Manager

read
Department:
Rural, Environment and Agricultural Development
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

MOOIFONTEIN LDC
PRIVATE BAG X1
MAHIKENG 2745

Tel: +27 (0)18 389 1392
Fax: +27 (0)18 381 1187

CHIEF DIRECTORATE: FARMER SUPPORT AND DEVELOPMENT

DIRECTORATE: MOOIFONTEIN LOCAL DEVELOPMENT CENTRE

TO :Mr O.S. ODUNIYI
UNISA (FACULTY OF ENVIRONMENT SCIENCE)

FROM : REBECCA GAASENWE
SPECIALIST AGRICULTURAL ADVISOR (CROP)

DATE : 02 AUGUST 2016

SUBJECT : APPROVAL TO CONDUCT AGRICULTURAL RESEARCH: MAHIKENG LDC

Your request datec 28 July 2016 regarding the above subject is most welcome to conduct research at Mahikeng LCD areas (Mooifontein). You are however requested to meet Assistant Director of Mahikeng Local Development office in order to commence with your research around Mooifontein areas.

Good luck for your research and it would be appreciated if you can send the dissertation to the office just for findings and recommendation. The research would assist our crop farmers.

R.M. GAASENWE
SPECIALIST AGRICULTURAL ADVISOR
MAHIKENG LDC 018 381 1392

WE BELONG WE CARE WE SERVE

APPENDIX E: PAPER PRESENTATION

7th EAAE PhD Workshop

"Challenges for young agro-food and natural resource economists facing the future"

Castelldefels (Barcelona, Spain) November 8th – 10th, 2017

HELD AT

The Center for Agro-food Economy and Development

(*CREDA*-UPC-IRTA)

Research institute in Castelldefels, Spain.

APPENDIX F: PAPER 1 ACCEPTED

Scholars Bulletin

An Official Publication of "Scholars Middle East Publishers"

Dubai, United Arab Emirates

Sch. Bull., Vol-4, Iss-2 (Feb, 2018): 136-145

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Impact of Climate Variability and Food Security Assessment among Small and Emerging Maize Farmers in North West Province of South Africa

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Abstract: This study was conducted in Nkanga Modiri Molema District Municipalities of North West Province of South Africa. The objective of the study was to determine the implication of climate change on livelihood (Household Food security) and determinants among the small and emerging small-scale maize farmers in the province. A total number of 346 questionnaires were administered to the farmers in the district using stratified random sampling technique. Data were captured and analyzed using the Statistical Package for Social Sciences (SPSS) version 23 and household food insecurity access scale (HFIAS) was employed to categories the food insecurity level. Descriptive analysis was first used to define the data followed by correlation matrix to reveal the variables that are relevant which were used in Binary Logistic regression analysis. However, the results of the analysis expounded some variables that are determinants to the impact of climate change on food security. Furthermore, the HFIAS findings elucidated that about 28.0% are mildly food insecured, 34% are moderately food insecured, while 21% are severely food insecured. It was recommended that the determinants factors such as the source of income, type of farm, land acquired, source of climate change information, the channel of information received on climate change, support received on climate change should be given more attention and addressed. Climate-smart agriculture, as well as conservative agriculture, should be introduced and improved where it has been practiced in the study area.
Keywords: Binary Logistic Regression, Climate change, Maize farmers, HFIAS, North West.

INTRODUCTION

The impact of climate change on livelihood is seen to be devastated as it affects the farming household negatively. Todaro and Smith [1], posited that the worst impact of climate change would be felt by the less resourced which results in poor livelihood status. A study conducted by Deressa *et al.*, [2] revealed that Africa's agriculture is badly affected by climate change. This is also supported by Apata *et al.*, [3] who maintained that Africa is generally acknowledged to be the continent most vulnerable to climate change. Fischer *et al.*, [4] asserted that developing countries had been more vulnerable to climate change than developed countries because of the predominance of agriculture in their economies and scarcity of capital for adaptation measures. Climate change could be viewed as one of the severe environmental menaces to livelihood, food insecurity and low agricultural productivity. According to Ziervogel *et al.*, [5] climate change is attributable to the natural climate cycle and human activities, which have adverse effects on agricultural production in Africa. The impact of climate change on food security results into hunger and malnutrition. A substantial number of studies have been conducted to examine the influence of climate change on crop yields and on agriculture in sub-Saharan Africa [6-8] hence, all revealed a negative impact on agriculture, food security, and production.

Livelihood capitals and agriculture have a common relationship as the majority of the household in the developing countries depend on agriculture directly or indirectly. This threatens rural livelihood capitals especially in sub-Saharan African resulting into poverty. The natural capital livelihood of the farm household is most affected followed by the financial capital livelihood. Food security is an example of social livelihood capital. Climate change and food security cannot be detached from each other as the impact of climate change is seen on agriculture and food production. Food security is defined by the United Nations' Food and Agricultural Organization (FAQ) as (i) the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports; (ii) access by individuals to adequate resources for acquiring appropriate foods for a nutrients diet; (iii) utilization of food through adequate diet, clean water, sanitation, and healthcare to reach a state of nutritional well-being where all physiological needs are met; and (iv) stability, because to be food secured, a population, household or individual must

have access to adequate food at all times [9]. According to the United Nations' Committee on World Food Security, food security is referred to as the condition in which all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. FAO [10] referred household food security as physical and economic access to adequate food for all household members without undue risk of losing such as access.

Problem statement

Climate change significantly affects rural communities particularly in Africa who depend on agriculture and natural forest resources for their livelihoods [11, 12]. Food and Agriculture Organization [13], reported that climate change is taking place in the context of other developmental stress such as poverty, low food production and many more. The challenge is that climate change threatens livelihood which gives rise to a high rate of unemployment as climate events destroy farm produce in the study area. In North West Province, poverty levels are high in the rural areas where most people depend on agriculture for their livelihoods. The proceeds from agriculture are a source of income to sustain and maintain a livelihood. The challenge here is that environmental and social consequences of climate change put livelihoods at serious risks of hunger, poverty, low farm income and makes it more difficult to reduce the proportion of people living in extreme poverty [12]. Changes in the rainfall pattern greatly affect biodiversity as well.

A noticeable gap and shortcomings were that rural livelihood is affected by climate change resulting in socio-economic problems such as poverty, hunger, low income, low food production, unemployment etc. However, a major focus has been on a national level, the lack of research findings to integrate activities, policies and agricultural practices to improve rural livelihood. This study is intended to fill in the gap by examining the impact of climate change on rural livelihood in the North-West province of South Africa, add to the existing literature, develop policy measures, agricultural practices and framework to improve rural livelihoods in response to climatic change and contribute to the body of knowledge.

Thus, there is a need to study the effect of climate change on livelihood, adaptation and mitigation strategies among small and emerging maize farmers. This will provide a sufficient reason to explore the effect of climate change on livelihood. The findings obtained will enable small and emerging scale maize farmers in the study area to understand better, the concept of climate change and livelihood. Policy makers and the stakeholders may also use the recommendation from the study to advice farmers about climate change effects and practices to improve farmers' livelihood.

METHODOLOGY

Data were collected using questionnaires, which consist of a logical flow of questions related to climate change and food security. Stratified sampling technique was used to administer the questionnaires to the farmers. The data were captured and analyzed using SPSS software and XLSTAT. Correlation matrix analysis was obtained to identify the variables that are associated with the study from the wide list of variables obtained from the questionnaires after which binary logistics regression model (BLRM) was used to determine if a household is food secured or not. Logistic regression is a multivariate technique used to study the relationship between a dichotomous dependent variable and one or more independent variables [14]. A dichotomous variable is a variable that takes only two values, 1 and 0 respectively.

Let Y be a binary response variable:

$Y_i = 1$ Household Food Secure i
$Y_i = 0$ Household Food Insecure i

$X = (X_1, X_2 \ldots\ldots X_k)$ be a set of explanatory variables which can be discrete, continuous, or a combination. x_i is the observed value of the explanatory variables for observation i. In this section of the notes, we focus on a single variable X.

Assuming that household food security is the function of household gender (x1), household age (x2), farming as a major income (x3), type of farm (x4) ….xn. The initial model will be given as:

$$\text{Logit}(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right)$$
$$= \beta_0 + \beta 1\, x_1$$
$$= \beta_0 + \beta 1\, x_{i1} + \ldots\ldots + \beta k x_{ik}$$

Then the logistic regression model can be expressed as:

$\text{Logit}(\pi) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta 0 + \beta 1 X i$ (1) or

$$ni = \frac{exp(\beta 0+\beta 1xi)}{1+exp(\beta 0+\beta 1xi)} \quad (2)$$

$$Y= \alpha + \beta 1 x_1 + \beta 2 x_2 + \beta 3 x_3 + \beta 4 x_4 + \beta 5 x_5 + \ldots\ldots + \beta k x_k + \varepsilon$$

Where,

The variable Ɛ is called the error term or disturbance. It is termed "noise" reflecting other factors that influence climate change awareness. It captures the factors other than x affecting y.

Y = dependent variable
×i = independent variables
βi = regression coefficients
α = is the constant term

The model for logistic regression analysis assumes that the outcome variable, Y, is categorical (e.g., dichotomous), taking on values of 1 (i.e., yes) and 0 (i.e., no). Hypothetically, population proportion of cases for which Y = 1 is defined as p = P (Y =1). Then, the proportion of cases for which Y = 0 is 1 - p = P (Y = 0). In the absence of other information, we can estimate p by the sample proportion of cases for which Y = 1. However, in the regression context, it is assumed that there is a set of predictor variables, X1...Xk, that are related to Y and, therefore, provide additional information for predicting Y.

Logit (Pi) = ln (Pi / 1-Pi) = α + β1×1 + ...+βn×n + Ut

Where,
ln (Pi / 1-Pi) = logit for farmers awareness choices (Yes or No)
Pi = Household food secure;
1 - Pi = Household food unsecure;
β = coefficient
×1 = covariates
Ut = error term

When the variables are fitted into the model, the model is presented as:
ln (Pi / 1-Pi) = α + β1×1 + β2×2 + β3×3 + β4×4.....+ Ut

In other to determine the food security level or category, Household Food Insecurity Access Scale (HFIAS) Generic Questions were used, which consists of 9 questions as being listed below:

- In the past four weeks, did you worry that your household would not have enough food?
- In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?
- In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?
- In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?
- In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?
- In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?
- In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?
- In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?
- In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?
- HFIA category variable is calculated for each household by assigning a code for the food insecurity (access) category in which it falls.

HFIA category	Calculate the Household Food Insecurity Access Category for each household. 1 = Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure Access HFIA category = 1 if [(Q1=0 or Q1=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0] HFIA category = 2 if [(Q1=2 or Q1=3 or Q2=1 or Q2=2 or Q2=3 or Q3=1 or Q4=1) and Q5=0 and Q6=0 and Q7−0 and Q8−0 and Q9−0] HFIA category = 3 if [(Q3=2 or Q3=3 or Q4=2 or Q4=3 or Q5=1 or Q5=2 or Q6=1 or Q6=2) and Q7=0 and Q8=0 and Q9=0] HFIA category = 4 if [Q5=3 or Q6=3 or Q7=1 or Q7=2 or Q7=3 or Q8=1 or Q8=2 or Q8=3 or Q9=1 or Q9=2 or Q9=3]

The Household Food Insecurity Access Prevalence was used to determine the percentage of household food security status. Food security levels were measured using the United States Agency for International Development Household Food Insecurity Access model. This study measures household food security by directly using the questionnaire-based techniques developed by Coates *et al.*, [15] for the United States Agency for International Development (USAID). These techniques and measurements are applied to the person most responsible for food and food provision in households. Indirect measures of food insecurity are: utilization of food security-related programs, income-based measurements of poverty, anthropometric measures, financial hardship indicators, dietary intake, and other nutrition and health parameters severely food insecure [16]. The HFIA categories households into four levels of household food insecurity (access): food secure, and mild, moderately and severely food insecure. Households are categorized as increasing food insecure as they respond affirmatively to more severe conditions and/or experience those conditions more frequently [15].

RESULTS AND DISCUSSION

Correlation analysis was used to find the relationship of a numerous number of independent variables that are related to the objective of the study as listed on the questionnaire. The result showed the following independent variable; household size, household gender, household age, the source of income, type of farm, land acquired, the source of information on climate change, channel of information received on climate change, support received on climate change are correlated to the dependent variable (food secure).

Source of income was statistically significant ($p<0.05$) and had a negative relationship to the objective of this chapter. Farmers who had no other job or extra source of income other than their farming activities (maize farming production) tend to be more knowledgeable, aware and adapt to climate change. They were concerned about their environment in relation to their farming activities because they needed to provide for their households and be food secured. They were, therefore, more conscious of the impact of climate change as an environmental factor responsible for low food production, unlike farmers who had other sources of income besides farming. Chigavazira [17] reported that household income is affected by climate change which results in low food production. In Indonesia [18], a decrease in rainfall in the 90-day period after the monsoon is associated with a 14 percent decline in per capita expenditures other than food. In the Philippines, climate variability, and in particular negative rainfall shocks, reduce household expenditures on food [19].

The type of farm from table 4, was significant ($p<0.05$) and showed a positive relationship on the impact of climate change on household food security. The result indicated that the type of farm was statistically significantly different to the impact of climate change on household food security. Various types of the farm such as individual farm, family farm, community farm, company farm and tribal farm were considered during the data collection, however irrespective of the farm type, the impact of climate change was observed which affect the household food security. This could be attributed to the fact that, a majority of the farmers' ranging from individual to tribal farm type depends largely on agriculture (maize production) to make their income. The majority of the farmers had no non-farm income, however, whatever type of farm they had, it's being maximized to realize an optimum profit.

The land is a fundamental factor of production in the agricultural sector. It has an essential role to play in increasing as well as sustaining agricultural production. Land acquisition was statistically significant ($p<0.05$) with a positive relationship to the objective of this chapter. The result showed how farmers acquire the land increased the probability of the impact of climate change on household food security by 20.7 percent. Farmers acquired lands through own finance, bond, LRAD, PLAS, restitution, inheritance, land affairs, and land hiring. Whatever land acquiring method used, it has an impact on food production in terms of quantity of food produced as a result of the availability of land space and its influence on the climate change and its variability. Cotula *et al.*, [20] reported that the issue of large-scale foreign land acquisitions is now a hot issue, especially in Africa. According to Kihwan Seo and Natalia Rodriguez [21] causal relationships among climate change, food security, and land grab make the current situation worse in Global South, where people already have been suffering from food shortages and severe weather events, and increase vulnerability to climate change. Each of these three elements adversely affects people in Global South in different ways that particularly threaten their livelihood, safety, and health.

Source of climate change information has a negative relationship on household food security and it was statistically significantly ($p<0.05$). It shows that source of information decreased the probability, or the likelihood decreased by 40.4 percent. There are different sources of information available for the farmers in the study area, which includes: flyers, magazine, radio, local newspapers, the internet, and the extension officers. The major source of information is the radio, farmer to farmer extension and extension officers. The source from which information is being received determined the effectiveness and farmers' adoption on adaptation which enhances food security. The same reported was made by Gabriel *et al.*, [22] farmers need information on the weather and climatic variations and extension agents are expected to be in regular contact with the farmers to disseminate information.

Information channel plays a crucial role in promoting *agricultural* productivity, increasing food security, improving rural livelihoods, and promoting *agriculture* as an engine of pro-poor economic growth. The channel of information on climate change increased the likelihood or the probability of food security by 32.9 percent and it was statistically significant ($p<0.05$). This could result from the fact that, extension officer works directly, hand in hand, visiting, assessing farmers' problems which become more effective and efficient for farmers to adopt innovations which can enhance their food production. Extension services provide an important source of information on the impact of climate change on household food security, as well as agricultural production and management practices. According to Nhemachena [23] better access to crop and livestock extension services has a strong and positive impact on climate adaptation strategies which has an influence on household food security. Benhin [24] noted that farmers' level of education and access to extension service are major determinants of adaptation measures to climate change. Improving access to extension services for farmers has the potential to significantly increase farmer awareness of changing climatic conditions as well as adaptation measures in response to climatic changes [25].

Institutional support received on climate change impact was statistically significant. The variable has a negative relationship with likelihood decreased by 17.8 percent. The support received by the farmers includes formal credit, insurance, farmer to farmer extension, relatives, subsidies. According to Gina and Ericksen [26] it was reported that institutional support for adaptation to food security is needed for rural farmers.

Table-1: Descriptive statistics of the variables

Description of Variables	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Are you food secured Yes = 1; No = 0	346	1	1	2	01.72	0.024	0.451	0.204
Household Size 1-3 = 1, 4-6 = 2, 7-9 = 3, 10-12= 4, 13-15 = 5	346	4	1	5	2.13	0.058	1.073	1.151
Household Gender Male = 1, female = 2	346	1	1	2	1.16	0.020	0.366	0.134
Household Age 18-30 = 1, 31-40 = 2, 41-50 = 3, 51-60 = 4, 61-70 = 5, 71-80 = 6	346	5	1	6	3.45	0.077	1.432	2.051

Farming As Major Income Yes = 1; No = 0	346	1	1	2	1.29	0.025	0.457	0.208
Types of Farm Individual Farm = 1, Family Farm = 2, Community Farm = 3, Company Farm = 4, Tribal Farm = 5, Other = 6	346	4	1	5	2.06	0.075	1.386	1.921
How Do You Acquire the Farm Own Finance = 1, Bond = 2, LRAD = 3, PLAS = 4, Restitution = 5, Inheritance = 6, Land Affairs = 7, Land Hiring= 8	346	7	1	8	5.09	0.110	2.048	4.194
Source Of Information on Climate Change Flyers = 1, Magazines = 2, Radio = 3, Local Newspapers = 4, Internet = 5, Extension Officer = 6, None = 7	346	6	1	7	3.25	0.048	0.897	0.805
What Channel Information Is Being Received on climate change Formal extension =1, Farmer to Farmer = 2 Family support = 3, Neighbours = 4, Municipalities office =5, Other = 6, None =7	346	6	1	7	2.14	0.066	1.226	1.504
Support Received on climate change Impacts Formal credit =1, Insurance = 2, Farmer to Farmer extension = 3, Relatives = 4, Subsidies = 5, Other = 6, None = 7	346	6	1	7	4.87	0.125	2.316	5.366
Valid N (listwise)	346							

Size Sample = 346

Table-2: Distribution of respondents according to food security status in the study area

	Food Secured	Frequency	Percent
	Yes	98	28.3
	No	248	71.7
	Total	346	100.0

Parameter estimates of the binary logistics regression model on food security and its determinants

Variables		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1[a]	Household Size	0.109	0.128	0.715	1	0.398	1.115
	Household Gender	-0.661	0.366	3.258	1	0.071	0.516
	Household Age	0.030	0.118	0.066	1	0.797	1.031
	Source of Income	-0.953	0.324	8.678	1	0.003	0.386
	Type of Farm	0.381	0.137	7.785	1	0.005	1.464
	Land Acquire	0.207	0.070	8.697	1	0.003	1.230
	Source of Climate Change Information	-0.404	0.137	8.716	1	0.003	0.668
	Channel of Information on Climate Change	0.329	0.157	4.412	1	0.036	1.390
	Support Received on Climate Change	-0.178	0.067	6.997	1	0.008	0.837
	Constant	2.526	0.991	6.493	1	0.011	12.497

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	332.235[a]	0.207	0.297

Source: Authors Computation, (2017).

Noted: $p < 0.05$; $p < 0.01$ is significant at 5% and 1% respectively.

Descriptive statistics to show what has happened in the past 30 days on Household Food Insecurity (Household Food Insecurity Access Scale (HFIAS) Generic Questions).

Table-3: Distribution of households worrying about not having enough food

	Households	Frequency	Percent
	Never	20	5.8
	Rarely	21	6.1
	Sometimes	173	50.0
	Often	132	38.2
	Total	346	100.0

Table-4: Distribution of households not eating preferred meal

	Households	Frequency	Percent
	Never	27	7.8
	Rarely	16	4.6
	Sometimes	189	54.6
	Often	114	32.9
	Total	346	100.0

Table-5: Distribution of households eating few kinds of food

	Households	Frequency	Percent
	Never	13	3.8
	Rarely	15	4.3
	Sometimes	200	57.8
	Often	118	34.1
	Total	346	100.0

Table-6: Distribution of households eating foods not preferred due to lack of resources

	Households	Frequency	Percent
	Never	41	11.8
	Rarely	30	8.7
	Sometimes	193	55.8
	Often	82	23.7
	Total	346	100.0

Table-7: Distribution of households eating smaller meals due to not having enough food

	Households	Frequency	Percent
	Never	46	13.3
	Rarely	51	14.7
	Sometimes	181	52.3
	Often	68	19.7
	Total	346	100.0

Table-8: Distribution of households eating fewer meals due to lack of food accessibility

	Households	Frequency	Percent
	Never	54	15.6
	Rarely	35	10.1
	Sometimes	151	43.6
	Often	106	30.6
	Total	346	100.0

Table-9: Distribution of households with no food due to lack of resources

	Households	Frequency	Percent
	Never	120	34.7
	Rarely	37	10.7
	Sometimes	124	35.8
	Often	65	18.8
	Total	346	100.0

Table-10: Distribution of households going to bed hungry due to lack of food

	Households	Frequency	Percent
	Never	124	35.8
	Rarely	35	10.1
	Sometimes	106	30.6
	Often	81	23.4
	Total	346	100.0

Table-11: Distribution of households spending the whole day without eating any food.

	Households	Frequency	Percent
	Never	117	33.8
	Rarely	48	13.9
	Sometimes	109	31.5
	Often	72	20.8
	Total	346	100.0

Household Food Insecurity Assess (HFIA) Category

Food and Nutrition Technical Assistance (FANTA) reported that a food secure household experiences none of the food insecurity (access) conditions, or just experiences worry, but rarely. A mildly food insecure (access) household worries about not having enough food sometimes or often, and/or is unable to eat preferred foods, and/or eats a more monotonous diet than desired and/or some foods considered undesirable, but only rarely. But it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating). A moderately food insecure household sacrifices quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions. A severe food insecure household has graduated to cutting back on meal size or a number of meals often, and/or experiences any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even as infrequently as rarely. In other words, any household that experiences one of these three conditions even once in the last four weeks (30 days) is considered.

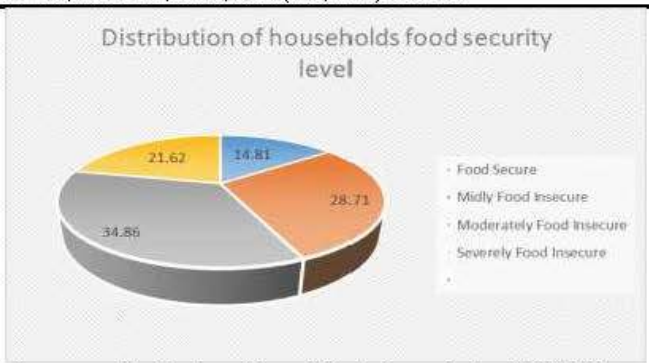

Fig-1: Percentage distribution of household food security level (HFIA Categories).

The findings from figure 1 above, indicated that 14.81 percent of households are food secure, 28.71 percent are mildly food insecure, 34.86 percent are moderately food insecure, while 21.62 percent are severely food insecure. This shows that majority of the household need to be food secured, several measures have to be put in place to increase food production and farmers' livelihood.

CONCLUSION

This study assessed the implication of climate change on livelihood, adaptation and mitigation strategies. However, the impact was observed on the household food insecurity as well as the factors responsible. It explored household food insecurity assess (HFIA) category and distribution of household food security level. In achieving these, correlation and binary logistics regression were used. Firstly, the correlation matrix helped to analyze independent variables that are related and correlated to the climate change and household food insecurity. Binary logistics statistics analysis revealed variables that determine the impact of climate change on household food insecurity among the small and emerging maize farmers in the study area. There was a statistically significant difference between the impact of climate change on household food insecurity and the following variables; source of income, type of farm, land acquired, the source of climate change information, the channel of the information on climate change, support received on climate change. This revealed that attention is much more needed on the variables that are significant in other to enhance and strengthen household food security in the face of climate change impact.

Descriptive statistics showed the Frequency distribution what has happened in the past 30 days on Household Food Insecurity. There were 9 questions which were asked from the households. The questions were referred to as Household Food Insecurity Access Scale (HFIAS) Generic Questions, which measured household food security by directly using the questionnaire-based techniques developed by Coates *et al.*, [15] for the United States Agency for International Development (USAID). Household Food Insecurity Access Prevalence was used to determine the percentage of household food security status. The HFIA categories households into four levels of household food insecurity (access): food secure, and mild, moderately and severely food insecure. However, the result of the HFIA showed the percentage distribution of household food security level in which 14.81 percent of households are food secure, 28.71 percent are mildly food insecure, 34.86 percent are moderately food insecure, while 21.62 percent are severely food insecure. This depicted that only a few of the household is food secured.

It is recommended that farmers should be taught, trained and educated on the different method of farming such as conservation agriculture (CA), climate-smart agriculture (CSA), sustainable farming (SA) and different adaptation measures as well as indigenous knowledge in other to adapt to climate change variability and events. The activities of extension services should be increased as many farmers claimed they are not well reached and supported. Farmers' support or group or cooperative should be encouraged among the farmers. The government should provide resources at the local level and endeavor the resources are channeled and received by the right people. The youth should also be encouraged in farming, perhaps through value-driven agricultural production in other to increase agricultural produce which as result can reduce the importation of food.

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APPENDIX G: PAPER 2 ACCEPTED

JOURNAL OF ECONOMICS AND BEHAVIORAL STUDIES (JEBS)
(ISSN 2220-6140)

Dated: August 09, 2018

Oduniyi, Oluwaseun Samuel, Antwi Micheal, Busi Nkonki-Mandleni
Department of Agriculture and Animal Health University of South Africa, South Africa
Mangosuthu University of Technology, KwaZulu-Natal, South Africa

Ref: JEBS-18-2295

Subject: Paper Publication

Dear Sir/Madam

Based on reviewers' evaluation your paper (JEBS-18-2295) titled: **DETERMINANT FACTORS TO CLIMATE CHANGE AWARENESS AMONG RURAL FARMING HOUSEHOLDS IN SOUTH AFRICA** has been accepted for publication. On behalf of our editorial board we are pleased to inform you that your paper will likely to be included for publication in August 2018 issue of the journal Vol. 10, No. 4. This is just to inform you that the journal is indexed/abstracted in:

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Date: 21 March, 2018.

Prof. Nkoki-Mandleni,
Department of Agriculture and Animal Health,
Faculty of Agriculture and Environmental Science,
University, South Africa.

Dear Prof. Nkoki-Mandleni,
EDITORIAL REPORT ON THE MANUSCRIPT: "Implication of Climate Change on Livelihood and Adaptation of Small and Emerging Maize Farmers in the North West Province of South Africa"

The above manuscript was received for editing on Tuesday, 13th March, 2018 with the following details:

Type of manuscript: PhD project
Author: Oduniyi Oluwaseun Samuel
Institution: University of South Africa
Number of pages: 208
Total word size: 40,460

The manuscript was thoroughly edited for grammatical and stylistic errors. The details of the corrections are provided below:

Categories of errors found: Concord, omissions and wrong use of grammatical words, tautology and wrong word choices.

Broad report on corrections done: Corrections were effected on grammatical words (mainly articles and prepositions) and connecting items were inserted where necessary. Errors of concord and subject-verb agreement were also corrected, wrong word choices and wrong phrasing of expressions inclusive.

Method of correction: All corrections are effected as track changes in the manuscript, and are attached as document, in addition to a clean, submittable copy of the same document. In other words, two versions of the edited works are prepared: a version showing the changes made, and a clean version in which the changes have been accepted.

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Thank you.

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