PERCEIVED EFFECTS OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION IN THE LOWVELD AREAS OF MPUMALANGA PROVINCE, SOUTH AFRICA

by

SEUN BOLUWATIFE AJALA

Submitted in accordance with the requirements
for the degree of

MASTER OF SCIENCE IN AGRICULTURE

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF KR MBATHA
CO SUPERVISOR: PROF MA ANTWI

August 2017

DEDICATION

This dissertation is whole-heartedly dedicated to Almighty God who has been my Alpha and Omega, my refuge, strength and my help in times of trouble.

DECLARATION

I, ‘Seun Boluwatife Ajala, declare that **“PERCEIVED EFFECTS OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION IN THE LOWVELD AREAS OF MPUMALANGA PROVINCE, SOUTH AFRICA”** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references. The work has not been submitted before for a degree or examination at any other university.

Signature _____ Date: 14 July 2017

Name: ‘Seun Boluwatife Ajala

Student number: 57634270

ACKNOWLEGDEMENTS

All praises and glory to Almighty God for His loving-kindness, endless mercy, favour, protection and grace that endureth forever from birth till this moment of my life. He is my father, the author and finisher of my faith who I look unto at all times. I will forever be grateful. Without Him, this research work would not be a success story.

I convey a special thanks to my supervisors, Professors Khanyisile R. Mbatha and M.A Antwi for their good spirit, endurance, encouragement, guidance, support and parenthood-like attitude towards me. They inspired me greatly through their unrelenting efforts at making me a success in life but not as a student alone. Words are not enough to express my gratitude, however, my sincere prayer is that the Almighty God will bless them and perfect all that concerns them.

My most unreserved appreciation goes to my dear parents Mr Simeon Kola Ajala and Deaconess Bola Lydia Ajala for their love, efforts, prayers, financial and moral support towards me; you shall reap the fruits of your labour in due season in Jesus name.

I owe my deepest gratitude to my siblings Oluwadamilare and Oluwafemi Ajala for always been there for me. I would not have asked for better siblings, you are the best. God bless you.

From the depth of my heart, my appreciation goes to my big brother Olusegun Odekunle and his family for the brotherly advice and always leading me through God's way. I love you.

I am also grateful to my South African family, the Malete's, to a special mother and wonderful older sisters, Khumotso and Joy. You have been there even when the storms of life arose and it seemed I would sink with the storm. Kea le rata.

I ever remain indebted to Mrs Victoria Dosunmu for your advice and contribution towards my success. Mummy, I love you. I am also grateful to my brothers and friends: Mr Tunde Ajibade, Mr Oyewole Israel. To my twin, Olawuni Olaoye Grace, I say thank you.

I also appreciate my pastors Dcn. Lanre Omolajaye and A/P Segun Oyebanji for always being there for me in times of need. More anointing for the work in Jesus name.

It is my greatest pleasure to show appreciation to a wonderful brother and friend in person of Mr Durowoju Olatunde, for always finding time for me out of your busy schedule to make this work a success. Ndi a livhuha.

I will be an ingrate if I did not acknowledge my friends Aisiolu Akinbayo Abayomi, Adedotun Opeyemi, Deborah Mwelesa-Mumbake Adedoja, Oke Adedayo and others I cannot mention their names for their various contributions towards my success. I love you all.

I also appreciate Ms Cathrine Lekganyane, Ms Maud, Ms Enelani, and Mr Jabulani Mokoena for their support.

It is a pleasure to thank the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs for permission granted me to do this research in the province. I also appreciate the extension officers that worked passionately with me and the people of Ehlanzeni district who made this dissertation possible i.e. the five local municipalities; Bushbuckridge, Mbombela, Nkomazi, Thaba Chweu and Umjindi that were interviewed. Ngiyabonga.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

AgriSA	Agriculture South Africa
BFAP	Bureau for Food and Agricultural Policy
CSAG	Climate System Analysis Group
CEEPA	Centre for Environmental Economics and Policy in Africa
DARDLEA	Department of Agriculture, Rural Development, Land and Environmental Affairs
DEA	Department of Environmental Affairs
FAO	Food and Agriculture Organization
GHGs	Greenhouse Gases
IFAD	International Fund for Agricultural Development
IFPRI	International Food and Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
NEPAD	New Economic Program for African Development
PDARDLEA	Provincial Department of Agriculture, Rural Development, Land and Environmental Affairs
SAI	South Africa Information
SAWS	South African Weather Services
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
Stat SA	Statistics South Africa
UN	United Nation
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nation Framework Convention on Climate Change
UNFPA	United Nations Fund for Population Activities

USEPA United States Environmental Protection Agency

ABSTRACT

The study was on the perceived effects of climate change on agricultural production among smallholder crop farmers in the Lowveld areas of Mpumalanga province, South Africa. A total of 351 farmers were randomly selected and well-structured interviews were scheduled that contained both close-ended and open-ended questions.

Data collected was analysed with descriptive statistical tools while logit regression model was used to analyse the relationship between the socio-economic characteristics of the farmers and their level of awareness of climate change The findings revealed that majority 33.9% of the respondents were 56 years and above and most (72.1%) of the respondents were male. Likewise, 68.4% were married while their major occupation was farming.

It was discovered that most (66.4%) of the farmers were not aware of the changes in climate in the study area. Only 52.7% stated that there was information on climate change. The impacts of climate change on crop production from the view of the farmers included (1) Reduced crop production levels and (2) No production, which have been affecting their livelihood diversely such as increase in socio-economic problems, reduction in income and increase in unemployment.

The result of the logit model analysis revealed a significant relationship between the age of the farmers (0.019), land tenure system (0.062), the manager of the farm (0.036) and the farm ownership (0.072) and their level of climate change awareness.

The study recommends that government as well as stakeholders' programmes designed to improve farmers' awareness of climate change and its impact on production should consider the aforementioned explanatory variables.

Keywords: Climate change, Greenhouse gases, Awareness, Vulnerability, Rain-fed, Lowveld, Mpumalanga, South Africa

CHAPTER ONE
INTRODUCTION

1.1 Background to the problem

The change in climate is directly or indirectly due to human activities (UNFCCC, 1992). The climate of the world has been warmer by 0.7^{o}C on average and between 1990s and 2000s being the warmest years (Watson, 2010). The effects of increased climate variability are evident, particularly in developing and least developed nations, where crop production is rain-fed; and people have limited strategies to acclimatize (Traerup and Mertz, 2011; Easterling *et al.*, 2000). According to Mandleni (2011), climate change will probably be exhibited in: firstly, changes in climatic conditions that are prolonged; secondly, seasonal variability and inter-annual that are increased; thirdly, extreme events of changes that are spread and lastly, catastrophic alterations of the ecosystems. According to FAO (2010) climate change is gradual changes in climate norms. Therefore, this change needs all countries to react and address climatic changes.

Climate change is mentioned as global warming (Oduniyi, 2013; Mandleni, 2011). This is a result of increasing temperatures and increasing levels of atmospheric CO_2 resulting from use of fossil fuels worldwide. Proliferation of greenhouses causes global warming that attenuate the ozone layer in the pursuit of livelihood and comfort of human being. Molua (2002), as cited by Coster and Adeoti (2015) named the gases as mainly CO_2, methane (CH_4) and nitrous oxide (NO_2). According to Mandleni (2011) global warming is a market failure that the world ever experienced because it is a public area that any country can pollute. The countries that does not pollute cannot be compensated for the benefit enjoyed by the countries that pollute (Mandleni, 2011).

Climate change has become more alarming to the sustainable agricultural activities of most nations and humanity (Ayinde *et al.*, 2010). This will result in the world experiencing higher temperatures and changing precipitation patterns than what we experience. The climate change is affecting every country of the world but is likely to broaden the gap between rich and poor countries (Coster and Adeoti, 2015; Mandleni, 2011; Ayinde *et al.*, 2010). Mendelsohn *et al.* (2001) indicated that third world countries will tend to experience the most suffering because of negative impacts. In these countries, climate change poses a serious threat and increases the vulnerability of the poor since they mostly depend on ecosystems. It was concluded that Africa's agricultural production is vulnerable and negatively affected due to erratic weather conditions causing farmers to take cognisance of the destructive impacts of

climate change on agriculture production (Apata *et al.*, 2009). It also calls for consideration in revamping the methods applied to determine climate change.

Africa contributes the least CO_2 with less than 4% of the global production yet it might suffer the most (Medugu, 2008). This will be due to the interaction of agricultural, political, biophysical, and socio-economic challenges to worsen the susceptibility of the region (Connolly-Boutin and Smit, 2016; IPCC, 2007). This has been referred to as a case of negative external impacts by economists, (Medugu, 2008). Although, beyond the growth in the intensity of climate change in sub-Saharan Africa was prophesied to cause alterations in the proliferation in the incidence of extreme weather such as droughts and floods, gravity of rainfall, upsurge in desertification and adjustment in some determined disease vectors. (Connolly-Boutin and Smit, 2016). This will cause changes in disruption of the growing seasons; reduced arable land and agricultural yields will be less in most parts of the sub-Saharan Africa.

Climate change affects crop production as this sector is sensitive and is one of the most vulnerable to climate variation (Maponya and Mpandeli, 2012; Idowu *et al., 2011*). Calzadilla *et al.* (2013) identified five factors through which climate change will impact on crop productivity that is changes in CO_2 fertilization, precipitation, temperature, surface-water runoff and climate variability. The climate change has affected crop productivity in many countries (Oduniyi, 2013; Maponya and Mpandeli, 2012; Ayinde *et al*., 2010; IPCC, 2007). This will be possible in poor countries, where crop production depends on climate (Apata *et al.,* 2009) and with unproductive adaptive measures (Ayinde *et al.,* 2010). Increased and frequent climate variability will have negative impacts on livestock production (Calzadilla *et al.,* 2013; Ayinde *et al.,* 2010; Apata *et al*., 2009).

Crop production depends on precipitation and temperature (Calzadilla *et al.,* 2013). Higher rainfall or irrigation will reduce the yield gap between rain-fed and irrigated agriculture. The (IPCC, 2007) articulated that temperature and soil moisture are important to the length of growing season and the development of crops. However, in arid and semi-arid areas, high temperatures will shorten the crop cycle and reduce crop production. De Salvo *et al.* (2013) explained that a higher atmospheric concentration of CO_2 improves plant growth, particularly of C_4 plants. This also affects water availability and increases water use efficiency (CO_2 fertilization). However, climate change in rainfall patterns, is important for rain-fed agriculture. The danger of climate inconsistency is reduced by irrigation. The irrigated farming systems are dependent on reliable source; thus they may be affected by spatial and temporal distribution of river flow (Calzadilla *et al.,* 2013).

In Africa, agriculture is the main source of livelihood for rural communities, which might alleviate unemployment on the continent (World Bank, 2013). In Africa, it is estimated that about 70% of the population depends on rain-fed agriculture (Connolly-Boutin and Smit, 2016; World Bank, 2009). The menace that climate change poses to the production of agriculture include crop and livestock husbandry. The significance of change in rainfall and temperature can impacts on livestock, directly or indirectly (Ayinde *et al.*, 2010). The upshot of animal performance, such as reproduction, growth and milk production can be altered by climatic variables such as humidity, air, rain and temperature. The quality and quantity of feed stuffs, grain, gravity, diseases' distribution and parasites can be influenced by climate change (Ayinde *et al.*, 2010).

Thornton *et al.* (2011) prognosticated that climate change will bring about scarcity of water which possibly might cause a reduction in livestock feed and pasture yield. Furthermore, changes in rainfall patterns will lead to epidemic of livestock diseases such as bluetongue in the Northern Europe and Rift valley fever in East Africa (Gould and Higgs, 2009). It was evaluated that there will be an approximated value of about 30% losses of all plant and animal species due to these diseases. Additionally, the standard of plant material was envisaged to diminish because of high temperature intensity and lowering their digestibility and degradation rates by livestock (Getu, 2014). This was distinctly possible to result in the reduction of livestock production making it to have a strong negative effect on food security and household income. Therefore, agricultural productivity remains a yardstick to measure the totality of agricultural sector and there should be a way to forestall the menace climate change constitutes in agriculture and livelihood of people in the region (Getu, 2014; Ayinde *et al.*, 2010; Apata *et al*., 2009).

Dwindling production of agriculture during a rapid population growth due to climate change is problematic. To control the changes influenced by climate need a great comprehension coping strategies (Coster and Adeoti 2015; Maponya, 2012). Various crops have different climate requirements. The intention is to provide useful elements for decision making hence the current study analysed the perceived effects of climate change on the crop production by smallholder crop farmers in Mpumalanga province of South Africa. This dissertation consists of five chapters. The first chapter introduces the challenges related to the effects of climate change on crop production. The second chapter reviews literatures regarding the effects of climate change on the agriculture and overview of the current situation. The methodology used to analyse the awareness on climate change among farmers is in third

chapter. The fourth chapter outlines the results and discussion while chapter five provides the conclusion and recommendation.

1.2 Problem statement

Research confirms that climate change might result in long-term threats for rural households in vulnerable regions like sub-Saharan Africa (Valdivia, Stoovogel, and Antle, 2012). The threat that climate changes constitute to developing countries include severe weather such as desertification, droughts, prolonged precipitation and floods. Droughts and desertification are expected in the southern and central part of South Africa (CSAG, 2008). The floods and prolonged precipitation are forecast as the effects of climate change on the physical environment. According to the IPCC (2007) there is a concern regarding the susceptibility of developing countries in the dilemma of climatic changes. Climate change has negative effects on agriculture (Galindo *et al.,* 2015; Bryan *et al.,* 2009). Predictions regarding climate change in South Africa indicated that certain animal species will be extinct due to climate change (Mandleni, 2011). Farmers will endure more negative effects than the positive effects. Though there is vast research on effects of climate change there is less information about perceptions of rural farmers (Jokastah *et al.,* 2013). To combat climate change, it involved two stages (1) to become aware that climate change has happened and (2) to make a decision to adopt a certain measure or not (Maddison, 2007). Based on the above reasons, identifying farmers' understanding about climate change is vital to helping to inform policy decisions on adaptation grounded on local perceptions and current autonomous adaptation strategies.

Therefore, the current study investigated the perceived effects of climate change on crop production and mitigation strategies against the negative future effects. It helped to determine perception of farmers regarding climate change phenomenon and agriculture in the in the study area. This is expected to improve the knowledge of crop farmers regarding climate change and policy formulation.

1.3 Objectives of the study

The main objective is to determine the perceived effects of climate change on crop production by smallholder farmers in Lowveld areas of Mpumalanga province, South Africa. The specific objectives were:

- To determine the socio-economic characteristics of the crop farmers in the study area.
- To determine the perceived effects of climate change by the crop farmers.

- To assess awareness of climate change among the farmers in the study area.
- To analyse the determinants of awareness of climate change among the crop farmers in the study area

1.4 Hypothesis of the study

The study hypothesised that:

- There is no significant relationship between the socio-economic characteristics of the farmers and their awareness of climate change.

1.5 Significance of the study

Previous studies proved that atmospheric greenhouse gas (GHG) concentrations increase due to anthropogenic activities and some of these changes are unavoidable though the world would apply best efforts to reduce GHG emissions (Connolly-Boutin and Smit, 2016; Valdivia *et al.*, 2012; Mandleni, 2011; Bryan *et al.*, 2009). There are high agricultural productions of third world countries will suffer the most. In 1988 some governments concerned with these negative effects had a meeting and initiated the Intergovernmental Panel on Climate Change (IPCC) The IPCC eventually resulted to the United Nations Framework Convention on Climate Change (UNFCCC). Their main objective was to alleviate GHG concentrations that will dampen the human activities interference with the climate (UNFCCC, 1992).

The formation of the IPCC is as a result of a threat to lives and food security that climate change poses because production of agriculture is the foundation of livelihood for rural communities in third world countries including SSA (Valdivia *et al.*, 2012). It is a known reality that 34% of gross domestic agriculture production contributes and employs about 70% of the population in this part of the world (Coster and Adeoti 2015). The crop farming in SSA depends mainly on rain-fed irrigation and covers approximately 97% of the total cropland. In some African countries, while some farmers were able to perceive variations in rainfall and temperature, some countries were not even aware of climate change. With all this evidence, climate change is here thus there is a drastic exigency for communities in the world to comprehend the notion of climate change and its threats.

According to Maddison (2007) as cited by Nhemachena *et al.* (2014) on the evidence from 11 African countries, it is revealed that even if farmers accurately perceive climate change, some may still fail to adjust because of limited access to information, adaptation technology options, markets and budgetary constraints amongst other factors. This showed the importance of ensuring that rural communities have the means and resources to implement the

various potential optimal adaptation strategies at their disposal to address current and expected effects of climate change impacts on crop production. Combating changes of climate is of two-stage process: (1) the initial stage is perceiving that changes in climate have occurred and (2) making decisions to adopt a particular measure or not (Maddison, 2007). Based on this and the above arguments, identifying how farmers perceive climate change is critical in helping to inform policy decisions on adaptation grounded on local perspectives and current autonomous adaptation strategies.

Therefore, this current research sought to determine perceptions of farmers on change of climate and its effects on crop production. The perceptions were compared with empirical evidence from climatic studies on trends on temperature and rainfall and impacts on livelihoods in the province and country at large.

1.6 Scope of the study

This study determined the perceived effects of climate change on agricultural production in the Lowveld area of Mpumalanga province, South Africa. Data were randomly collected among farmers within the five local municipalities (Bushbuckridge, Mbombela, Nkomazi, Thaba Chweu and Umjindi) that made up the Lowveld region of the province. Data on level of awareness and farmers observation were also collected to know how climate change has been affecting the farmers in the study area. Climatic variables were also collected to compare farmers' perceptions and empirical climate change evidence.

1.7 Limitations of the study

The province did not have historical data about climate regarding to agriculture of the study area and this was solved by getting the required data from the South African weather services. Additionally, some farmers could not provide accurate answers to the questionnaire regarding climate change observations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviewed existing scholarly literature on the farmers' perceptions about and adaptations to climate change. The chapter also reviewed ways in which different authors have explained variability of climate change, its impacts and coping in relation to the parts of the sub-Saharan Africa (SSA). It also discussed the concepts of climate change, the economic, social and environmental impacts plus cognizance to change in climate.

2.2 Concept of climate change

Climate is the weather conditions predominant in a certain area over a long period and a change in climate is usual weather patterns. The United States Environmental Protection Agency, (USEPA, 2014) described climate change as a significant change in rain, wind and temperature or lasting for an extended period. According to the UNFCCC, 1992 climate change is attributed to anthropogenic (directly or indirectly) resulting in worldwide atmosphere over comparable period of time just to mention a few and is in line with the fact that most climatic scientist agreed.

Climate change is already a reality but argued in a global terms, yet its effect differs among different regions of the earth. The IPCC (2001), assessment report stated that the world has experienced an estimated 0.6^{o}C increase in global mean annual temperature and it was anticipated that the warming trend will continue at proliferating rates. To understand further the effects that climate change hold on cities, more the scientific research climate change across regions and worldwide have to understood.

2.2.1 Climate change observations

The climate of the world is changing were prophesied to be unprecedented in current history of human (Adger *et al.,* 2003). The global increase of average temperature is approximately 0.6^{o}C during the twentieth century (IPCC, 2001). The IPCC (2007) assessment report quantified that average temperature escalation from the mid twentieth century is the result of increased in anthropogenic GHG levels.

Different kinds of vulnerability studies, (Coster and Adeoti, 2015; Maponya and Mpandeli, 2012; Valdivia *et al.*, 2012) were utilized to determine the effects of climate change on agricultural system. There is a physiological problem of plants to get and optimally use

moisture by increase in temperatures which makes soil evaporation from the soil to be quick. The increase in temperature results in rise of plant transpiration.

Several studies had stated carbon emissions as a key problem in climate change but failed to communicate the positive impact of carbon emissions on agriculture (crop production). The climate change has negative effects on agriculture and food security which is based on assessing C_4 crops (maize and sugar cane). Climate change is a reality experienced globally.

2.2.1.1 Climate change from international point of view

Anthropogenic climatic changes are among the most visible problems of the environment. Therefore climate change is being perceived from different perspectives. Ishumael (2013) identified that climate change has direct impacts which happen to be important asset for livelihoods. Some linkage that existed between community and climate change include negative impacts it has on the susceptible populations that are unable to build resilience.

It was anticipated that climate change will threaten food security (FAO, 2010). Climate change positions an additional threat to poor farmers and rural communities and weak institutions are also under threat (Oduniyi, 2013). The atmospheric temperature of Asia and Pacific regions will increase proportionally by 0.5ºC-2ºC by 2030 and by 1ºC-7ºC by 2070 according to the climate model of the IPCC. The weeds and insect infestations, as well as diseases related to the change of climate usual cause damage in developing countries (Mendelsohn and Seo, 2007). In South America there will be a decrease in arable land value as precipitation and temperature increases, except in areas where irrigation system is involved. In extreme climate scenario; the loss of 14%; 20% and 53% loss of farmer's revenue will be experienced by 2020, 2060 and 2100 respectively. Furthermore, small pieces of land are in jeopardy of climate change and large ones are quicker to respond to precipitation increase. In Latin America, the gravity of climate change effects will vary from region to region within countries (De La Torre *et al.*, 2009). For example, in Mexico climate change will benefit some regions and based on the outcome of the findings, there is tendency that the negative effects will increase as the analyses get closer to the equator and the southern part of the continent may benefit from climate change.

The seasonal producer will be affected the most and there is no adequate evidence to differentiate impacts between small and large producers but farmers will suffer from climate change (Mendelsohn *et al.*, 2007). Mandleni (2011) affirmed that Mexico is vulnerable to

economic decrease due to climate change. Anderson and Bausch (2006) established the link between climate change and natural disasters. Extreme weather events have been part of life since the nineteenth century but were not consistent in the natural cycles but were made consistent with the anthropogenic influence of GHGs. The extreme weather events responsible for natural disasters are extreme temperature resulting in heat waves, high level precipitation or lack of precipitation consequently flood or drought and storms including windstorms and hurricanes. Many European countries experience these natural phenomena due to climate change (Maponya and Mpandeli, 2012; Valdivia *et al.*, 2012; Mendelsohn and Seo, 2007).

Mandleni (2011) reported a study that was conducted by Slater in 2007 on effects of change in climate on agricultural growth, natural resources and access to markets. From these results it was observed that annual rain in the semi-arid and arid areas of third world countries was highly variable resulting in degradation of important natural resources. Furthermore, disasters such as floods will threaten infrastructure and as a result, it was envisage that transport cost.

The Ricardian model of Mendelsohn *et al.* (2001) compared the possible impacts of climate change between developed and developing countries using data from India and United States. According to results India was more likely to experience more negative effects than the United States. Developmental level has of a country has notable effects on the sensitivity of climate change. Mendelsohn *et al.* (2007) used this model between Brazil and United States, it was discovered that both countries are facing increase in temperature while Brazil will affected more adversely.

It has been proven by several researches that climate change is already here and all mankind is at risk of extreme weather events even in wealthy nations (Anderson and Bausch, 2006).

2.2.1.2 Continental standpoint on climate change

Africa, as a continent, is the least contributor of all the continents to climate change but will suffer the most from its repercussions (Coster and Adeoti, 2015). Many factors serve as instruments in aggravating the current climate change variability effects in Africa and will have negative effects on the continent abilities to cope with climate change (Boko *et al.*, 2007). The severe exploitation of natural resources poses additional threat.

Climate change will result negative in effects on Africa's agricultural production (Bryan *et al.*, 2009) supporting that crop yields in many developing countries are negatively affected (BNRCC, 2008; Deressa *et al.*, 2008). These effects of change in climatic variables

on the arable land will threaten economy of the developing countries that depend heavily on agriculture and weather related sectors (Mendelsohn and Dinnar, 1999).

The relationship between the profit of farmers and climate revealed that low annual rain rainfall and high temperature will result in reduced net profit (Molua and Lambi, 2007). Furthermore, if climate change and global warming are left unchecked, they will cause adverse effects on Nigerian livelihoods (Idowu *et al*., 2011). This will result in altered rainfall regime and there will be occurrence in floods and other natural disasters like flood, ocean and storm surges.

Fischer *et al.* (2005) as cited in the UNFCCC (2007) expressed that irrigated agriculture will suffer the most in many African countries. The arable land will be lost resulting in lower agricultural production will occur under the influence of change in climatic variables and will also cause a decline in crops.

Climate change literatures have suggested various climate change impacts that are defined to different parts of the continent and food insecurity, human insecurity, ecosystem destabilization, flood, erosion, economic impacts, conflicts aggravation are recommended consequences in Africa (Akiyode and Daramola, 2011). Hence, the aforementioned possibilities will negatively contribute to socio-economic development on the continent and will intensify the continent's vulnerability to further climate change impacts one after the other.

2.2.1.3 Regional position on climate change

Africa's climate variability is bound to increase due to rate of occurrence and intensity level of extreme weather conditions. This is caused by accelerated human activities on the continent; therefore Southern African region is not an exception to climate change. Oduniyi (2013) pointed out that Namibia experienced yearly warming rate of 0.023^{o}C between the years 1950 and 2000 and also described the nearby Indian Ocean in the region has been warmed by more than 1°C since 1950. The region's climate is predominantly semi-arid, there is notable disparity in yearly rainfall and the trend may continue with the wetter seasons (Mubaya *et al.*, 2012).

Drought is perceived as the most challenge in the region and there were challenges like prolonged floods in Mozambique plus tremendously increased annual rainfall in Malawi. During 2000 there were floods in parts of Southern Zambia and few regions of Zimbabwe (Mubaya *et al.*, 2012). It was acknowledged that the excessive rainfall in Malawi was considered to lead to food shortage in 2002. The study that was conducted by Mubaya *et al.* (2012) described the socio-economic life of the farmers being negatively affected and decrease

in crop production as problems to climate induced drought and floods. Furthermore, it was revealed that availability of fresh water in the region and health related problems will cause change in climate. This is a threat to Southern Africa as a region is based on the serious environmental and social effects. Farmers in this region are dependent on availability of natural resources for their livelihoods.

2.2.1.4 Climate change based on national perspective

In South Africa climate change is troubling farmers. Ziervogel *et al.* (2014) explained that climate change is a key concern within South Africa. Benhin, (2006) reported that South Africa is getting hotter, using data from 1960 to 2003 and stated that annual average temperature increased by 0.13^{o}C. Mandleni (2011) stated that climate change in South Africa has detrimental economic, environmental and social effects. Climate change that includes rapid increase in temperature constitutes a threat to agricultural productivity which depends on weather. Generally, South Africa has been proclaimed as a dry country (Oduniyi, 2013) therefore; it is expected to be one of the countries that will suffer the most by 2025. Water resources in the northern part of the country were nearly used up and developed (Oduniyi, 2013). In contrary, the well-watered with significant underdevelopment and little used resources is in the South eastern region of the country. The CSAG (2008) predicted drought and desertification in the southern and central part of the country while floods and prolonged precipitation are also forecasted. Climate change can cause temperatures to increase and reduction in rainfall may exert pressure on limited water sources resulting in poor agricultural yield and food security (Benhin, 2006).

2.2.2 The climate systems

2.2.2.1 The atmosphere

The atmosphere is a layer of gases surrounding a planet on other material framework that is held in place by the gravity of that body. The atmospheres predominantly dominated by nitrogen (N_2) which is 78% volume mixing ratio and oxygen (O_2) which is 21% volume mixing ratio. The trace gases, such as CO_2, methane (CH_4), nitrous oxide (N_2O) and ozone (O_3) have effects on the amount of energy that is stored within the atmosphere and the earth's climate is conspicuous.

These greenhouse gases, with a total mixing ration in dry air of less than 0.1% by volume, play an important role in the Earth's budget (Baede, *et al.* 2001). Nitrogen and oxygen do not have any interaction with the emission of infrared radiation of the earth and also have a finite interaction with the solar radiation. Consideration of human's influence on the emission

of GHG levels is basic subject in understanding climate change globally because industries also contribute.

These greenhouse gases trap heat within the lower atmosphere that is trying to escape to space, and in doing so, make the surface of the earth hotter, this heat trapping is called natural greenhouse effect, and keeps the earth 33°C warmer than it would otherwise be. In the last 200 years, man-made emissions of greenhouse gases have enhanced the natural greenhouse effect, which may be causing global warming (Enviropedia, 2016).

Although, considering human's influence on the concentration of Greenhouse gas emissions (GHGs) are basic subject in understanding climate change globally. CO_2 and other greenhouse gases are added to the atmosphere through human activities and industries that strengthen the natural greenhouse effect and may cause a significant warming trend. Energy flow occurs between climate system and atmosphere (Enviropedia, 2016).

2.2.2.2 The hydrosphere

All subterranean water and surface liquid are referred to as the hydrosphere. The subterranean water consists of saline and fresh water. The former consists of sea and oceans water while the latter includes lakes, rivers and aquifers. The oceans play a primordial and complex role in climate regulation. Large amount of energy (solar) are absorbed, stored and transported by the oceans. They also dissolve and store CO_2 in great quantities. This heat are been moved by ocean currents from warm equator to the colder poles. Moisture is another form of heat transfer from the ocean. Evaporating waters from the ocean's surface that is released when rain is formed by vapour condensation. The energy between atmosphere and oceans have effects on change of the climate.

2.2.2.3 The cryosphere

The sea ice, glaciers and ice sheets of the world are collectively recognised as cryosphere and have a relatively impact over earth's climate. The cryosphere importance on climate change is its enhanced solar radiation reflectivity instead of absorbing it. There would have been much higher temperature on the earth surface without cryosphere because more energy will be absorbed by the earth instead of reflected and this will increase warming of the earth.

2.2.2.4 The biosphere

Biosphere contains all living organisms inhabiting on the earth both on the land and inside water. Land vegetation and soil control the process of energy received from the sun and how it returned back to the atmosphere. The radiation that is has long-waves is a medium where some of this energy is been returned back to the atmosphere (Baede, *et al.* 2001).

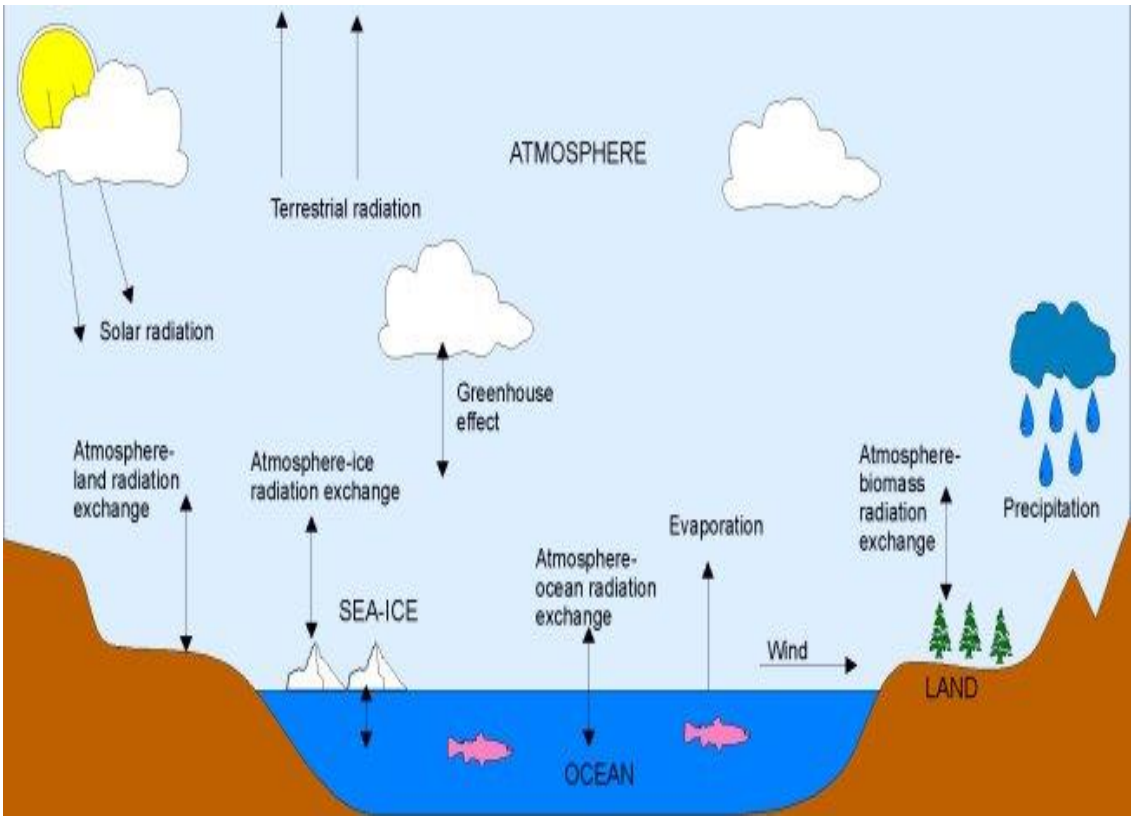

Figure 2.1: Schematic view of the components of global climate system source: Environpedia 2016

2.3 Agriculture and climate change

Agriculture and climate change cannot be separated. Agriculture has been partly responsible for emission of greenhouse gases. Crop production is at risk due to the menace climate change constitute to it. Agriculture has influenced food security, culture and economic activities. Howden *et al.* (2007) stated that agriculture is highly vulnerable to changes of climate. For the estimated growth in the world's population and food demand per capital to be met, an increase in agricultural production will have to be ongoing, which should eventually double the present production. Agronomic sustainable and effective adaptation practices can alleviate negative effects of change in climate.

2.4 Impact of climate change

Climate change is the major environmental challenge that is facing the whole world today (Oduniyi, 2013; Mandleni, 2011; Idowu *et al.,* 2011). It is a reality that affects us all but its effect is unequally felt (Coster and Adeoti 2015; Mandleni, 2011; Ayinde *et al.,* 2010). Climate change constitutes more danger to the developing countries compared to the developed nation. This is due to the economies of the developing nations that evolve round climatic variables and they have low response capacity to climate change (Traerup and Mertz, 2011). Environmental scientists declared that climate change is caused by warming of the earth's climate system which made them to be interchanging climate change with global warming but different from each other. From various definition of global warming which shows it as a mean temperature increase of the atmosphere near the surface of the earth and contribute to changes in global climate patterns, therefore, global warming have been adversely affecting the whole world generating many unfavourable situation (IPCC, 2007). There might be challenges faced by some professions and industries (i.e. weather and climate linked profession such as agriculture, tourism) from climate change.

Climate change impacts is categorised into three for the purpose of this research work, which includes social impacts, economic impacts and environmental impacts.

2.4.1 Social impact of climate change

Social impact of climate change is the social changes that climate change generates or brings into existence through its action on human being. The USEPA (2014) stated that the life of human beings is designed current climate conditions. The effect of climate variability will be felt on food production across the entire globe and this will alter the social life of the people. Food production plays an influential role in human society but the increase of CO_2 in the atmosphere is threatening it and increased temperature and extreme weather events are a menace farmers have to deal with in recent time. The social life of the people that climate change affects includes health, overpopulation due to migration and conflicts among people and communities; transportation systems as well as energy and water supplies can be negatively affected by climate change.

2.4.1.1 Climate change impact on health

Change in climatic variables will have effect on the human health and everything in her environment. Much of the mortality from heat waves is related to cardiovascular, cerebrovascular and respiratory diseases and this is concentrated in elderly persons and with

individuals with pre-existing illness (Haines and Patz, 2004). Furthermore, Maponya (2010) identified malaria epidemics, dengue and other vector-borne diseases as a principal effect of climate change in Asia.

The IPCC (2007) identified higher temperature accompanied by heat waves with high intensity and frequency in the Northern America and this is a risk to the health of the people living in such environments. All these changes in climatic will affect the health of the people in the developing countries and the under-developed world (Haines and Patz, 2004).

Climate change could also have deleterious adverse impact on mental and occupational health and its adverse effect would be worsened by food insecurity, hunger and malnutrition and also, increase in malnutrition and death as well as injury and diseases caused by extreme weather events like storms has been reported (IPCC, 2007; Haines and Patz, 2004). Additionally, the aftermath of this may be conflicts and war as communities fight for food or clean water to drink (Haines and Patz, 2004). The health impacts include physical injuries and increase in diarrhoeal diseases, particularly developing countries where malnutrition may also increase.

2.4.1.2 Climate change impact on population

The world's population is drastically increasing with a growing rate of 1.13% per year (UNPF, 2016) with the African continent having the highest population growing rate and countries like Niger republic having the record of the world's fertility rate where women have an average of 7.4 children (UNPF, 2016). People in search of social enjoyment like social amenities tend to move to urban areas which make this region of the world to be congested and overpopulated and low population density in the rural and urban areas with distinct vulnerability on climate change impacts (USEPA, 2014). The heat waves were defined as a major concern in the urban areas and this is because cities absorbed more heat during the day than the rural areas.

As a result of congestion in the cities, increase in heat waves, drought or violent storms in the cities would affect a larger number of people than in the rural areas. Likewise higher temperatures and more extreme weather events tends to have effect on the quality of water been produced, energy cost will also be affected, humans' comfortability and health issue also tends to be affected by changes in climatic variables.

2.4.1.3 Climate change impact on agricultural production

Agriculture is a significant sector to human existence. Besides providing the world with food, crops and livestock that are been grown and raised, it also contributes immensely to gross domestic product, export earnings and employment of each country of the world. Climate is essential to agricultural production regardless of advancement of technological approaches to the sector. Increase in both temperature and CO_2 might be of an advantage to some crops in some regions likewise being able to also have a detrimental effect on some other crops.

Climate change will have impact on both the yield and the price of the crops. There will be outstanding impacts on crop yields by changes in climatic variables (temperature, rainfall and humidity) and the intensity and frequency of extreme weather events, which could have a predominant effect on prices of agricultural produce. Maponya (2010) stated that the negative impacts of climate change on crop yields are pronounced in Africa, as agriculture sector accounts for a large share of GDP.

USEPA (2014) stated that warmer temperatures may make many crops grow more quickly, but warmer temperatures could also reduce yields and crops tend to grow faster in warmer conditions. However, for some types of crops (grains), faster growth reduces the amount of time that seeds have to grow and mature and this can lead to yield reduction. According to FAO (2010), 36 African nations were among the 50 nations whose food supplies were at risk and this is due to factors like high poverty rate, extreme weather events, and poor road networks to transport farm produce from the farm, poor storage facilities which have made Africa to be vulnerable to high food prices. Consequently, climate effect negative impact on crops will generate low production and cause the price of farm produce to increase and have a drastic effect on man's social lives while positive effect will have an advantageous impact on human by reducing the level of poverty among men.

The IPCC (2007) describe the livestock industry to occupy 40 percent of agricultural production worldwide and provides livelihood and food security to approximately 1 billion of the whole universe. Climate change affects livestock either directly or indirectly. The direct effects of climate variables such as air, temperature, humidity, wind speed and other climate factors influence animal performance such as growth, milk production and wool production (Ayinde *et al.,* 2011; Niggol and Mendelsohn, 2008). While the climate change can also affect livestock indirectly by affecting the quality and quantity of feedstuffs such as pasture, forage and grain and also the severity and distribution of livestock diseases and parasites (Ayinde *et al.,* 2011; Niggol and Mendelsohn, 2008).

2.4.1.4 Impact of climate change on water resources

According to USEPA (2014), water resources are essential to both society and ecosystems. Likewise. we rely on a dependable, clean supply of drinking water to keep our health. Water is also an important factor to agriculture, energy production, navigation, recreation and manufacturing. All these uses put pressure on water resources, stresses that are likely to be aggravated by climate change (USEPA, 2014). However, climate change impact on water resources differs from region and places, it can lead to an increase in water demand in a region while it narrows water supply, likewise water shortage in some region will be less a problem than increase runoff, flooding or sea level rise (USEPA, 2014). Therefore, the unbalancing will be a problem to the increasing human population, ecosystems, agriculture, manufacturing companies and energy production and can lead to reduction in water quality as well as damage infrastructure used for water delivery and transportation.

2.4.1.4.1 Impact of climate change on water demand and water cycle

Water cycle is the process whereby water circulates between the climate system involving precipitation as rain, fog, snow and dew and returning into the atmosphere through evaporation and evapotranspiration. According to USEPA (2014), warmer temperatures increase the rate of evaporation of water into the atmosphere, in effect increasing the atmosphere's capacity to hold water; therefore, intensifying evaporation rate can dry out some region and make excessive rainfall in other regions. However, alterations in hydrological cycle have impact on water demand in an environment because water is required by animal and humans to flourish.

2.4.1.4.2 Impact of climate change on water quality and water supply

The evaluation of water condition in comparative to the requirements to human need or purposes or to biotic species is known as water quality (Johnson, *et al.*, 1997) while many areas of the world currently face water supply issues (USEPA, 2014) because demand for water continues to increase as population grows. The areas that have experienced lesser rain in recent years as well as increase in the severity and length of droughts will be of concern (USEPA, 2014) and quality of water in such area will be affected. Excessive rainfall will affect the quality of water in such regions because this can lead to increase in soil erosion, leaching resulting increase the amount of sediments, pollutants, animal waste and other materials into the water.

Increase on the amount of runoff could also cause problems for the infrastructure as severe systems.

2.4.2 Economic impact of climate change

Climate change has a lot of impact on the society, which makes the impact of climate change to be interconnected to each other. Climate change had hampered growth of many nations in the world which has caused havoc in man's daily life activities connected to it which can result to loss of job, agricultural production, energy production to mention but a few. Deressa *et al*. (2005) measured the economic impact of climate change on South African agriculture and discovered that temperature and precipitation were found to significantly affect net revenue per hectare across production seasons. Gbetibouo and Hassan (2004) claimed that rise in temperature has a positive effect on net revenue while the impact of rainfall reduction is negative but Mendelsohn *et al.* (1994) contended that climate change may have economic benefits for agriculture without CO_2 fertilization. Another economic impact of climate change is in coping costs, when the society finds a way to mitigate or cope with it, which shows that coping is likely to be a costlier step to reduce elements of climate change.

2.4.3 Environmental impact of climate change

Climate change has caused damage on properties and infrastructures, likewise production loss. Climate change is also a threat to security of human life and will cause migration of people because of disasters like flood, drought, hurricanes which can also cause civil unrest among communities. Another key impact of climate change on the environment is land degradation, which will deprive the soil of its nutrients. Climate change will also affect the ecosystems, recreation and the coastal areas because some species of plants and animals will go into extinction.

2.5 Impact of agriculture on the environment

Environment is described as a domain in which human, animals or plants live together or operate. This can also be illustrated as the natural world as a whole or in a particular geographical area especially as affected by human activities. Environment can be classified into two namely: natural environment and manufactured environment while agriculture is the art of land cultivation, rearing of animals for man use. The impact of agriculture to the environment is considerably determined by the different methods of agricultural production adopted by the farmers. Basically, the effects of agriculture to the environment depend on

farmers' production practices. However, agriculture and environment are indirectly connected to each other as farming techniques influence emissions to the environment but in addition to other climatic variables such as temperature and rainfall.

Hayo *et al.* (2002) stated that agricultural environmental effect can be measured based on farmers production practice which is "means-based" or on the effects these practices have on the state of farming system or on emissions to the environment ("effect-based"). For example, for the objective quality of groundwater, indicators considering fertilisation (e.g. amount of nitrogen applied) or the establishment of cover crops (expected to decrease leaching) are means-based, while indicators reflecting nitrate in the soil at crop harvest or nitrate lost to groundwater are effect-based (Hayo *et al.*, 2002). Therefore, there are a lot of factors involved in the environmental impact of agriculture, which vary from the soil, to water, air, animal and soil diversity, plants, human, and the food itself (Wikipedia, 2016).

Climate change, deforestation, irrigation problems, soil degradation and waste remain some of the environmental issues related to agriculture. However, agricultural impact to the environment can be classified into two based on the agricultural practices, which are negative effects of agricultural applications and positive impact of agricultural applications.

2.5.1 Negative effects of agriculture on the environment

As environmental conditions affect agricultural practices, agricultural practices also have effects on environment i.e. the global flowing of greenhouse gases is being affected by agriculture. Agriculture has been in existence for decades and its serves as a source of livelihood and sustenance for many over the world. Agriculture is one of the major source of CO_2 emissions and it has been a leading cause in the increase of carbon in the environment (Rodriguez's *et al.*, 2004).

While that is no longer the case, it can be established that the present agricultural practices, while it is key to humanity are harmful to our environment. It is evident that harmful pathogens and chemicals are in our water because agriculture and levels of greenhouse gases in the atmosphere is intensifying as a consequence of agriculture.

2.5.1.1 Deforestation

The conversion of a forest land to non-forest use is called deforestation. One of the major causes of deforestation is clearing of land for agricultural purposes. The major reason for destroying forest is to obtain agricultural land (Onder, Ceyhan and Kahraman, 2011). As a result of agricultural land obtaining, greenhouse gases are created at the same time. Deforestation causes loss of habitat for millions of species and a driver of climate change. It is

a known fact that trees absorb CO_2 out of the atmosphere and most of the carbons are released into the atmosphere when forests have been destroyed to open agricultural land, however, deforestation aggravates climate change. Removal of trees can also cause extreme fluctuation of temperature.

2.5.1.2 Irrigation

Irrigation system in agriculture is of great value to yield and quality in arid and semi-arid regions. The ability of drawing water from the ground, rivers, lakes, overland flow and to distribute it over areas is called irrigation. There are effects which include rising of ground water, reduction in downstream flow of river, evaporation increase in the irrigated area, waterlogging (Onder *et al.*, 2011). In addition, irrigation alters the atmospheric circulation, delivering rain to different downwind areas. Additionally, soil salinity occurs due to excessive irrigation (Sylvain and Hayo, 2005).

2.5.1.4 Pollutants

Diverse agricultural chemicals such as fertilizers, herbicides and pesticides are used and some become pollutants through usage (excessive or misuse) and ignorance (Onder *et al.*, 2011). Agricultural pollution has an immense effect on the environment. Excessive or misuse of these chemicals can cause leaching whereby it will enter into the soil and enter the groundwater and get into food products and result into death or severe damage of aquatic organisms and human.

2.5.2 Positive effects of agriculture on the environment

As the negative effects of agriculture on environment exist and has a positive effects too. The truth is just that the negative impact has overshadowed its positive effect. Oxygen production in agricultural areas is more than the one produced by the forest and empty areas of land so the poison of the air decreases depending on CO_2 reception.

2.6 Awareness/knowledge of climate change on farmers' decision making

Climatic variability has been a challenge that farmers have been constantly facing and is envisaged to have a detrimental effect on agricultural production particularly in Africa (Oduniyi, 2013; Mandleni, 2011). Therefore farmers' knowledge on climate change is vitally important to protect livelihoods of the poor and to guaranty food security. Since agricultural production remains a major source of income for most rural communities (World Bank, 2013); it is of paramount importance for policy makers to know farmers perception to climate change

to help their decision making on the menace that changes in climatic variables are causing the agricultural communities.

Information received and the size of the farm had an impact on climate change awareness and helps farmers in decision making on climate change (Maponya and Mpandeli 2012 as cited by Oduniyi, 2013; Benhin, 2006). This shows that farmers with more information about climate change will be able to understand what climate change is and will know the type of climatic variable that is changing in the community and will be able to inculcate this into production processes. In addition, Deressa *et al.* (2008) stated that farmers' perception of climate change was related to the age of the head of the household, knowledge of climate change, wealth, social capital and agro-ecological settings help farmers to make proper mitigation and adaptation decision on climate change. Furthermore, the major barriers that can affect farmers' decision-making on climate change included lack of information about weather, poverty and lack of information on adaptation strategies (Fosu-Mensah *et al.,* 2012). Farmers have noticed changes in weather condition but did not have knowledge or information about it particularly small-scale farmers. This is due to their inability to access information either through different media source and extension services, which would have a drastic effect on their decision-making on the problem climate change is causing either to mitigate or to adapt.

Additionally, Aphunu *et al.* (2012) stated that, farmers were aware of climate change but they have low knowledge about its causes and impacts. Most of the farmers relied on their personal experience on the farm rather than on the media and extension services as a source of information. Poor farmers might not be aware or have a low level of knowledge on changes in climatic variables and base on this, creating awareness on climate change will serve as a pivotal measure to confront climate change impact on agricultural production (Adebayo and Tukur, 2003). Furthermore, Oduniyi (2013) asserted that despite the fact that majority indicated various level of awareness, their understanding on the phenomenon and consequences varied significantly while their knowledge about the causes are generally low. Consequently, different studies on climate change awareness have shown that farmers might be aware of climate change occurrence, but most of them did not have comprehensive information about it and its effects.

2.7 Summary

This chapter elucidate climate change as a fact, which is affecting the whole world. It was expressed in the literature that climate change is any significant change in measures of

climate lasting for an extended period. An overview of climate change established on international, continental, regional, national and provincial levels was stated. Many as periods of extreme weather events such as severe drought, heavy precipitation, flood and hurricanes are perceived as the climate change. This chapter further gives an explanation to impact of climate change based on social, economic and environment. Furthermore, agricultural impacts on the environment were discussed together with farmers' knowledge of climate change on decision-making.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology adopted for this research. It shows where the area is situated on the map, likewise it explicates the population comprising of diverse race found in the study area. This section also indicates the local municipalities in the district where the study was carried out. It contains the data collection, data reliability and validity, variable measurements and the logit model) that was used for inferential analysis.

3.2 Study area

The study was conducted in the Mpumalanga province. The province is located in the eastern part of the country (longitude 30.6167 and latitude -29.8167) with 494 m from sea level. The province is the second smallest province in the country with 6.3 percent of the country's land area after Gauteng province that is 1.4 percent in total land area (Stat SA, 2011). The total population of the province is 4 039 939.

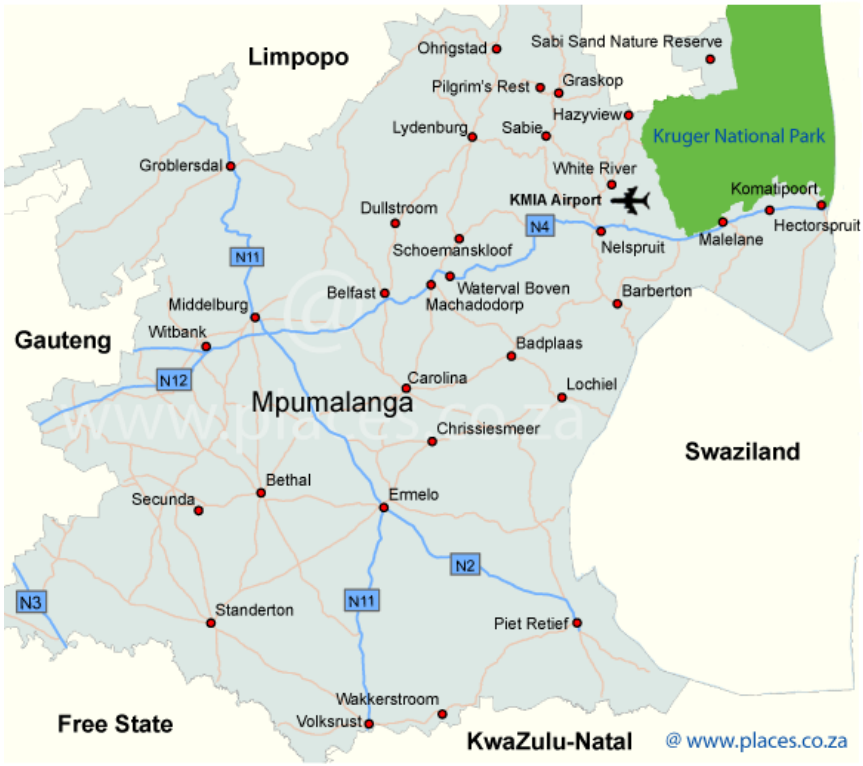

Figure 3.1: Map of Mpumalanga province

Source: Wikipedia (2016)

Mpumalanga province harbours people with different languages and diverse culture with 27.7% of the total population speaking siSwati, 24.1% isiZulu, and 10.4% speaking Xistonga and 10.1% speaking isiNdebele. Mpumalanga province has three districts (Ehlanzeni, Gert Sibande and Nkangala) and 18 local municipalities. The provincial headquarter is located in Nelspruit (Mbombela) which is the business hub of the province. Approximately 68% of the province is used for agricultural purposes. The major crops are maize, sugar cane, barley, wheat, and some leguminous crops. Also cultivated in the province are subtropical and deciduous fruits, vegetables, cotton, citrus, tea, coffee and tobacco (Wikipedia, 2016). Natural grazing extends over approximately 14% of Mpumalanga province. The dominant products are poultry, beef, wool, mutton, and dairy. The choice of the study area is due to climatic differences of drier Highveld region and Lowveld which is humid and hot and both are found in the province.

This Lowveld region has five local municipalities (Bushbuckridge, Nkomazi, Mbombela, Thaba Chweu and Umjindi). Agriculture takes 35.5 percent of the main economic sector in the district with different crops like maize, sugar cane, citrus, groundnuts and forestry being the major plant production while animal production like cattle and sheep rearing is common. Mbombela (previously known as Nelspruit) is the capital of Mpumalanga province. East of Ehlanzeni district shares border with Mozambique (Wikipedia, 2016).

Figure 3.2: Map of Ehlanzeni district

Source: Mpumalanga Municipality map, Wikipedia (2016)

3.2.1 Agro-ecological zones

There are various agro-ecological zones in South Africa as indicated in figure 3.3. Based on bio-climatic and growth form information, Rutherford and Westfall (1986) defined six biomes in the country but the savanna biome was sub-divided to include the "thicket" category, which predominates the river valleys of the eastern and southern coastal region (Low and Rebelo, 1996). Mucina and Rutherford (2006) further categorise the country's biomes into nine namely desert, nama karoo, succulent karoo, fynbos, grassland, savanna, albany thicket, the indian ocean coastal belt and forest.

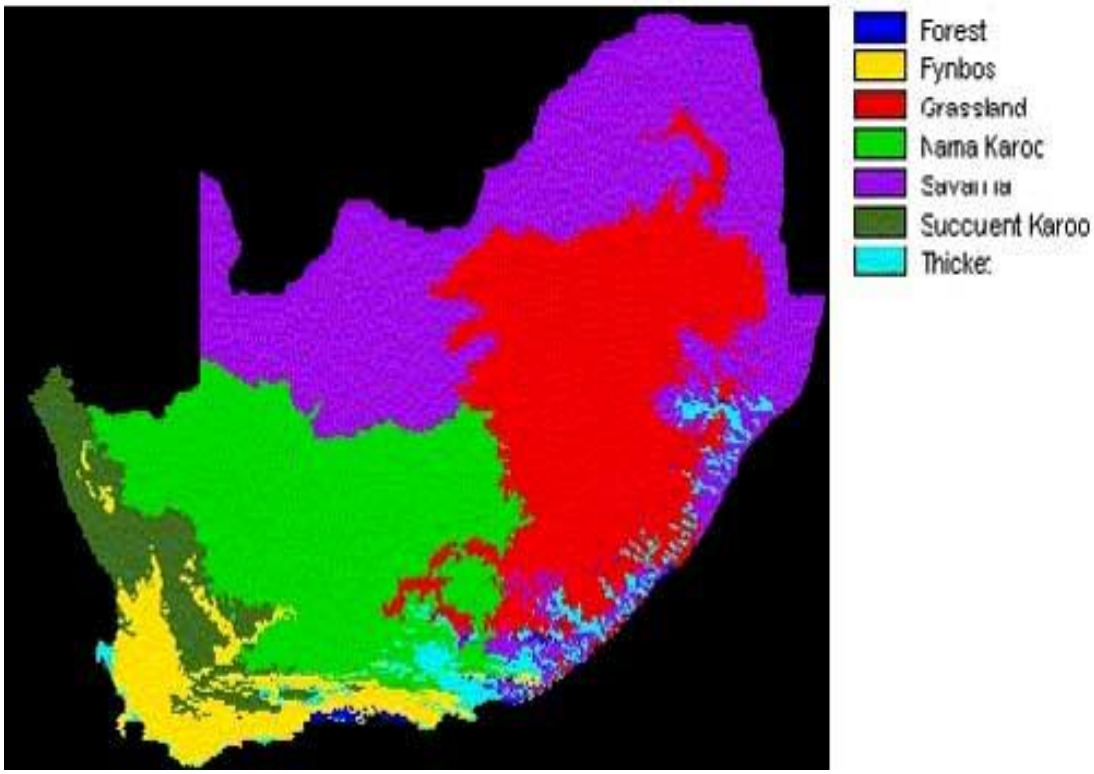

Figure 3.3: The agro-ecological zones in South Africa

Source: South Africa Explored (2017)

3.2.2 Climate in South Africa

South Africa is a semi-arid country because it has a mean rainfall of approximately 450 mm (SAWS, 2009). South Africa climatic conditions generally range from the Mediterranean in the south western corner of the country to the temperate in the interior plateau and subtropical in the northeast. Most of the country has warm, sunny days and cool nights. Rainfall generally occurs during summer (November through March), although in the southwest around Cape Town, rainfall occurs in winter (June to August). Temperatures are influenced by variations in elevation, terrain and ocean currents more than latitude. There is, however, wide regional variations in annual rainfall (fig. 3.4), from less than 200mm in the Richtersveld on the border with Namibia to more than 1000 mm in the mountains on the south of Western Cape province.

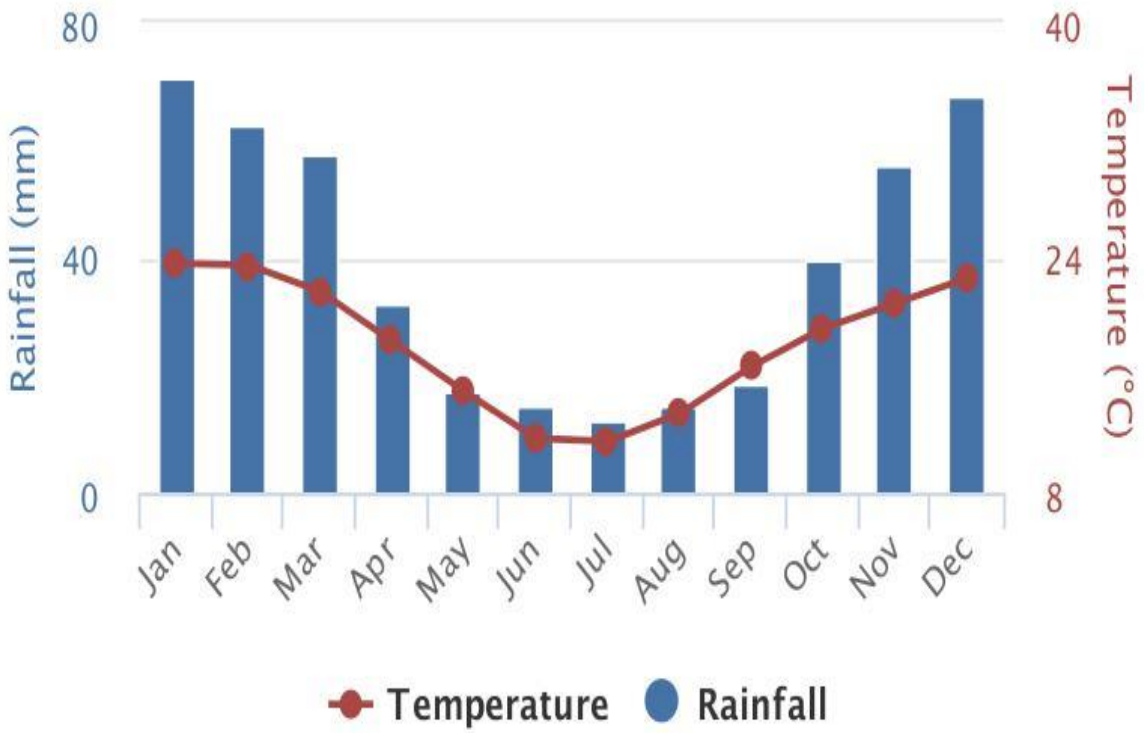

Figure 3.4: Average monthly temperature and rainfall for South Africa from 1991-2015

Source: Climate change knowledge portal of the World Bank (2017)

3.2.3 Climate in Mpumalanga province

Weather in Mpumalanga is naturally determined by its topography. Mpumalanga is a province of two halves, namely the high-lying grassland savannah of the Highveld escarpment and the subtropical Lowveld plains. The western side of the province on the Highveld escarpment is like a rise of tropics, an ascent into uncompromising range of temperatures. The west is drier, hotter and much colder than the rest of the province.

The Highveld experiences summer rain and has a summer (October to February) to winter (April to August) range around 19°C with average temperatures in contrasting seasons of 26°C and 8°C of the Lowveld which enjoys relatively plentiful summer rainfall (an average of around 620 mm falls between September and March) and mild to hot subtropical conditions.

3.3 Research design

The research design of a study outlines the basic approach that researchers use to answer their research question (Polit and Beck, 2004). Fowler and Aaron (2010) defines a

research design as the overall proactive plan for obtaining trustworthy answers to the questions that have been posed for the study; and for handling some of the difficulties that could be encountered during the research process**.** Small-scale farmers were interviewed using a structured questionnaire based on the number of small-scale farmers in Ehlanzeni district.

3.3.1 Research approach

Kumar (2005) simply define a research approach as an outline of techniques, procedures, philosophies and methods that a researcher will follow to achieve the research objectives. On the other hand, an approach to research are plans and the process for research that cover the steps from wide assumptions to detailed methods of data collection, analysis and interpretation (Creswell, 2014).

A combination of both quantitative and qualitative approaches were used in this study. In other words, this study used a mixed method research approach. A mixed method research according to Creswell (2014) is an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data and using distinct designs that may involve philosophical assumptions and theoretical frameworks in a research study. In addition, Johnson *et al.* (2007) stated that a mixed method research is kind of research that integrate quantitative aspects and qualitative methods for a comprehensive purpose of understanding and validation.

The core assumption of this form of inquiry is that the combination of quantitative and qualitative approaches provide a more complete understanding of a research problem than either approach alone (Creswell, 2014). Based on the questions that this study answered, the researcher use convergent parallel-mixed methods.

This is a form of collecting both qualitative and quantitative forms of data at roughly the same time and then integrates the information in the interpretation of the overall results (Creswell, 2014). Both quantitative and qualitative data were merge together in order to provide a comprehensive analysis of the research problem. The qualitative data was converted to a numerical code during analysis which help to correlate quantitative data with quantified qualitative data.

3.4 Population of the study

The sampling was carried out in such a way that population was divided across the five local municipalities that made up the Lowveld areas of Mpumalanga province. There were a

total of 10 891 farmers that practice small-scale crop production in the study area as informed by the data provided by the Department of Agriculture and Rural Development, Mpumalanga Province. The population was informed based on the numbers of small-scale crop farmers in each local municipality. The dominant crop in each municipality was also a determinant in selecting the population size.

3.5 Sample size and sampling procedure

The specific study areas included Bushbuckridge, Mbombela, Nkomazi, Thaba Chweu and Umjindi local municipalities. The small-scale farmers practice crop agriculture in these local municipalities. The criteria for participation was that farmers must be farming for at least one farming season and especially in practising crop production and willing to participate.

A multistage sampling technique was utilized for the study. The purposive random sampling in the study area was based on the four types of crop considered in this research. Firstly, there was a purposive selection of local municipality with the highest production of each crop in the district. Second, a purposive selection of villages in each local municipality was done and lastly about 351 farming households that were mainly into crop production were selected randomly from the list of smallholder crop farmers obtained from the extension officers from each local municipality.

3.6 Data collection

Both quantitative and qualitative designs were used in this research. The data on annual temperature, rainfall, and humidity for past 20 years were acquired from the South African Weather Services. Data were collected in the Lowveld areas of Mpumalanga province, South Africa. The data were collected by structured questionnaires which targeted smallholder crop farmers. Information collected included demographics, socio-economic characteristics and perceptions on climate change as well as agricultural production aspects from the areas selected for the study.

3.6.1 Data collection procedure

Permission to collect data was granted by the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) which was passed in a communiqué to the district and all the local municipalities of agriculture where the research was carried out. The data were collected via face to face interviews of the farmers where

structured and a detailed questionnaire written in English and translated to local languages served as the data collection instrument. The sample frame was designed to address the objectives and to ensure strict adherence to statistical specifications for accuracy. The survey was conducted between February and May 2016. The Provincial Department of Agriculture allowed the research to be carried out freely by communicating to the district and local municipalities. The extension officers in each local municipality helped in securing appointments with productive crop farmers in their localities where questionnaires were administered.

Questionnaires were arranged in blocks of topic of questions to address issues related to climate change and crop production. The questionnaire cut across generalities about socio-economic characteristics of farmers, crop cultivated, land characteristics, and cognizance, impacts of change in climate and perceived effects on crop production, coping measures and perceived adaptation options were divided into four sections of A-D.

Section A was based on socio-economic features of the farmers, cultivated crops and land characteristics. Questions ranging from the age of respondents, gender, marital status, educational status and household size of the respondents were asked under this section. Furthermore, questions on crops cultivated and land characteristics such as land tenure, the owner of the farm, size of the farm and who manages the farm were asked.

Section B covered climate change information and cognizance. The questionnaire contains questions like if farmers were aware of climate change and if they perceive the change in their locality. The respondents were asked if there is awareness program in their environment and how the information they got from the awareness program in their environment makes difference in their production.

Section C was based on farmers' observation of climate change. Questions that inquired about the respondents' perceptions on some climatic variables such as rainfall, drought, increased temperature and strong wind both on short term and long term were asked. Likewise, questions that looks into how change in climate have affected crop production, livelihood and the impact on food security in the study area was asked.

Lastly, section D was on adaptation measures. The researcher tried to know if the farmers are coping to the changes over the years and the local adaptation strategies been used by the farmers. Questions was also put in place to know reason why farmers were unable to adopt an adaptation measures if they were unable to cope with the effect of climate change.

The researcher with the extension officers conducted the interviews and data collection together. The objectives of the study were explained to the participants during the interviews. Furthermore, secondary data of the climatic variables (rainfall, humidity and temperature)

figures for the past 20 years of the study area were collected from the South African weather services and crop production for the past 20 years also were collected from the national department of agriculture. The secondary data was converted to numerical codes during analysis which help to correlate quantitative data with quantified qualitative data.

3.7 Data analysis

The statistical analytical methods that were used for this study include both descriptive and inferential methods. The descriptive analyses included means, frequency distribution and percentages. The inferential method involved the use of logit model to analyse the factors influencing the awareness of climate change among the smallholder crop farmers in the study area. Descriptive analysis was carried out on the collected data from the empirical evidence for specific objectives 1, 2 and 4. The independent variables used in the inferential analyses are presented in Table 3.7

Table 3.7 The independent variables used in the logit analyses

S/N	Independent variables (X)	Variable label	Expected effect
1	X_1	Age of the farmers (in years)	+
2	X_2	Gender (male = 1, female = 0)	+
3	X_3	Marital Status (classified)	-
4	X_4	Educational Status (classified)	+
5	X_5	Household Size (continuous)	+
6	X_6	Source of Income (continuous)	+
7	X_7	Farming experience (continuous)	+
8	X_8	Farming as major occupation (dummy)	+
9	X_9	Land tenure system (classified)	+
10	X_{10}	Who owns the farm (classified)	+
11	X_{11}	Who manages the farm (classified)	+
12	X_{12}	Size of the farm (continuous)	-
13	X_{13}	Receive information on climate change (dummy)	+
14	X_{14}	Observe climate change (dummy)	+
15	X_{15}	Perceptions on long term rainfall (categorised)	+
16	X_{16}	Perceptions on long term temperature (categorised)	+
17	X_{17}	Farming experience (continuous)	+
18	X_{18}	Does information received on climate change make difference? (dummy)	-

3.8 Reliability and validity

This section confirms the validity of the research work, through the way the information were gathered. It shows how the research tool was tested against ambiguity.

3.8.1 Validity

According to Golafshani (2003), validity is in quantitative research that determines whether the research measures what it intended to or how frank the research outcomes are. Researchers determine the validity by asking a number of questions. The questionnaires should address all characteristics of the studied issues. Two specialists in agricultural economics

critically assessed the specific objectives of the study, the models for analyses and the questionnaire to ensure that appropriate data were collected. The researcher adhered to validity of the study to ensure that the research is scientifically reliable.

3.8.2 Reliability

This is producing similar results under consistent condition. Reliability refers to the accuracy of measurement. It is easy to obtain replication of data when dealing with human beings based on the following factors:

- The respondent may have been sensitized on subject matter and thus influences their response
- There might have been an attitudinal change which may also influence the result of the test
- Behavioural change may also influence the test result making it unreliable

In this study, the questionnaire was pre-tested and piloted on five respondents before collection of data to improve its reliability. The respondents used in the pretesting were not interviewed in the main interview. The researcher distributed all questionnaires to all participants. Clear instructions were given to the participants with assistance of interpreters.

Questionnaires were answered by the participants in the presence of the researcher. It only shows that reliability is necessary but not sufficient condition for validity. Therefore, it is the responsibility of the researcher to ensure a high level of accuracy.

3.9 The logit model

The logit model used by the study was based on the logistic distribution. The logit model is also called the Logistic regression model and it is used to model a dichotomous outcome variable. The dependent variable of the study was dichotomous. The log-odds of the outcome are modelled as a linear combination of the predictor variable in a Logit model. The Logit function is specified as the inversed sigmoid When the function's parameter represents a probability (p), the logit function provides the log-odds, or the logarithm of the odds p/(1- p). Farmers who are aware of climate change is represented as 1, otherwise 0. The logit of a number probability between 0 and 1 is given by the following formula:

$$P_i = P_r\,[Y_1 = 1] = \frac{e^{Bx}}{1+e^{Bx}} \text{ ---------- } (i)$$

$= \lambda^{\{B^1 x\}}$

Where λ logistic cumulative distribution

The odd ratio, which defines the probability of awareness to non – awareness is given as:

$\frac{Pii}{l-Pi} = e^{Bx}$ ---------- (ii)

From equation (i)

$l - P = \frac{e^{xbx}}{1+e^{-xb}}$ ---------- (iii)

Rearrangement of these expressions gives

$L = \log\frac{P}{l-P_1} = \log P - \log\{l - P\}$ ---------- (iv)

$= -\log[l + e^{-xp}] - [\log\left[e^{-x\beta}\right] - \log[l + e^{-x\beta}]$

$= x^1\beta$

L = logit or the log of the odd ratios and analysis based upon the logistic distribution is often called logit analysis.

$\beta^1 x = \beta_0 + \sum \beta_1 x_1 + U_1$ ---------- (v)

Where

e = the natural logarithm

$\boldsymbol{\beta_0}$ = constant term

β_1 = vector of coefficients

x_1 = vector of the explanatory variables

U_1 = error term

3.10 Ethical consideration

Research ethics is a set of attitude from the researcher that guarantee some regard for the privacy, rights, integrity and confidentiality of those that participated in the research. On the other hand, ethics is a set of moral principles which offers rules and behavioral expectations about the most correct conduct towards participants, organizations, sponsors etc. (De vos *et al.*, 2015). To make sure this research was ethically acceptable and to strictly abide by the University's policy on ethics, the research proposal was approved by the ethics committee of the institution.

The researcher also seek a written consent of the provincial department of agriculture to carry out this study within the confines of the province and letter was sent to key people responsible for climate change within the province so as to access their database and other information that helped this research work.

The study used human participants, hence, the participants were treated as an autonomous agent and were informed about the benefit that this work had on their livelihood and in combating climate change in their locality. The researcher made sure that no harm happened to research participants in particular and people in general. Information supplied that is not for public consumption by the participants was treated with utmost confidentiality and the data were used solely for the main purpose of this research.

3.11 Summary

This chapter presented information about the study area. It also discussed the sample selection methods and the way in which data were collected and analysed. The logit model was specified and estimated. The dependent and explanatory variables used in the study were also presented including their expected effects. the data collection instrument was presented in detail and its validity and reliability tests were explained; and a total of 351 smallholder farmers were interviewed. The findings of the study were discussed in detail in chapter four.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter has the interpretation and discussion of the results of the research. The results of the descriptive statistics and inferential analyses are presented. The results are presented mainly in the form of tables and graphs. The results were discussed and where possible compared and linked to literature.

4.2 Results and discussion of socio-economic aspect of the study

4.2.1 Categories of farmers in the study area

Table 1 shows the different farming categories practised in the study area as informed by the secondary data collected from the Provincial Department of Agriculture, Rural Development, Land and Environmental Affairs (PDARDLEA). Majority (54.98%) were smallholder farmers while 44.12% were into subsistence farming. Commercial farmers in the district amounted to be 0.49%. Likewise communal and land reform farmers were 0.34% and 0.02% respectively. This implies that smallholders and subsistence farming dominated the area of study. This finding supported Altieri *et al.* (2012) that majority of African farmers are smallholders, with two thirds of all farms below 2ha and 90% of farms below 10ha. Farmers in the study area practice "low-resource" agriculture producing the majority of grains, legumes and tubers crops consumed in the region.

Table 1: Frequency distribution of farming categories in the study area

Farmers category	Frequency	Percentage (%)
Commercial farmers	75	0.49
Communal farmers	52	0.34
Land reform	3	0.02
Smallholder	8476	54.98
Subsistence farmers	6795	44.12
Total	15401	100.00

Source: PDARDLEA (Database, 2016)

4.2.2 Farming activities in the study area

Table 2 revealed different enterprises ranging from animal production, aquaculture, crop production, horticulture, mixed farming and community farming. These farmers were involved inenterprises. The major farming is crop production, which was 70% while farmers that were into animal production were 22.30% of the total farming population in the study area. The remaining percentages of farmers were into other types of farming. The implication is that farming enterprises are unequally distributed in the study area and farmers are majorly into crop and animal production. This is related to the findings of DAFF (2012) that smallholder farmers are majorly into either crop or animal production (on small-based plots relying almost on family labour).

Table 2: Frequency distribution of different types of farming activities in the study area

Farmers enterprise	Frequency	Percentage (%)
Animal production	3580	22.30
Aquaculture	14	0.09
Crop production	10891	70.70
Horticulture	717	4.70
Mixed farming	8	0.05
Community	191	1.24
Total	15401	100.00

Source: PDARDLEA (Database, 2016)

4.2.3 Numbers of farmers available in each local municipality of the study area

As shown in Table 3, 54.98% of farming activities took place in Nkomazi local municipality, 27.52% of the farmers in Bushbuckridge, Mbombela local municipality had a total number of 9.76% of the farmers while Thaba Chweu had 4.47% of the total farmers and Umjindi local municipality had 3.28%. Having this frequency and percentage helped in selecting the sample size where farmers that were into crop production were solely sampled from each local municipality.

Table 3: Frequency distribution of farmers in each local municipality of Lowveld area

Local municipality	Frequency	Percentage (%)
Bushbuckridge	4238	27.52
Mbombela	1503	9.76
Nkomazi	8467	54.98
Thaba Chweu	688	4.47
Umjindi	505	3.28
Total	15401	100.00

Source: PDARDLEA (Database, 2016)

4.2.4 Personal characteristics of the sampled respondents by local municipality

Table 4 reveals the local municipalities where the research was carried out in Ehlanzeni district of Mpumalanga province. The following local municipalities of the Lowveld areas were selected for the study: Bushbuckridge, Mbombela, Nkomazi, Thaba Chweu and Umjindi. Populations were distributed among the five local municipalities in the district based on the frequency of crop farmers as informed by the secondary data. A purposive sampling was conducted to select local municipality that were majoring in each crop as informed by the extension officer based on the crops.

Table 4: Distribution of sampled respondents by local municipalities

Local municipality	Frequency	Percentage (%)
Bushbuckridge	96	27.4
Mbombela	34	9.7
Nkomazi	193	55.0
Thaba Chweu	16	4.6
Umjindi	12	3.4
Total	351	100.00

Source: used data from the study

4.2.5 Age of the respondents

As reflected in Table 5, 10.3% of the respondents were between age range of 19 – 35 years. Respondents of the age range of 36 – 45 years of age constituted 25.1%, while those in 46-55 years of age accounted for 30.8% and the remaining 33.9% were found to be 56 years of age and above while farmers below 18 years of age were not considered to be part of the research. This implies that the most participants were 56 years of age and above. This is similar to the findings of Maponya and Mpandeli (2012) that young people do not see farming as a lucrative profession and prefer other occupations. Maponya and Mpandeli (2012) further explained that the computer and industrialisation era, enable youth not to concentrate on agriculture but to technology related occupations. According to, Bayard *et al.* (2007) as cited by Oduniyi (2013) affirmed that age is positively correlated to agricultural adaptations for climate change. Additionally, Ibrahim *et al.* (2015) stated that older farmers are believed to be more experienced thus impacting positively on their productivity. In addition, Binswanger-Mkhize (2014) stated that the declining interest of the youths from farming was also one of the factors contributing to poor performance in agricultural practices.

Table 5: Frequency distribution of respondents according to age

Age group	Frequency	Percentage (%)
19 – 35	36	10.3
36 – 45	88	25.1
46 – 55	108	30.8
≥56	119	33.9
Total	351	100.0

Source: used data from the study

4.2.6 Frequency distribution by gender

According to the results in Table 6, 72.1% of the respondents were males while the proportion of female respondents was 27.9%. The reason for having higher number of male farmers may be due to the drudgery nature of agricultural activities. Oduniyi (2013) found that female farmers cannot be as active as men in agriculture. Coster and Adeoti (2015) stated that male authority was attributed to the strenuous farming due to high dependency on physical labour. Generally, women unlike men, have limited access to critical agricultural inputs and consequently disadvantage their participation in farming.

Table 6: Frequency distribution of respondents by gender

Gender	Frequency	Percentage (%)
Male	268	72.1
Female	104	27.9
Total	372	100.0

Source: used data from the study

4.2.7 Marital status of the respondents

Table 7 shows that 18.5% of the participants sampled were single and 68.4% of the respondents were married, 3.1% were divorced while 7.7% were widowed and 2.3% of the respondents were separated. It implies that majority of the farmers were married. Marital status may impact on the knowledge of households on climate change through any member of the farming household.

Table 7: Frequency distribution of respondents according to marital status

Marital status	Frequency	Percentage (%)
Single	65	18.5
Married	240	68.4
Divorced	11	3.1
Widowed	27	7.7
Separated	8	2.3
Total	351	100.0

Source: used data from the study

4.2.8 Educational qualifications of the respondents

Table 8 showed participants with secondary education and post-secondary education were 29.6% and 24.5% respectively. However, 27.9% of the respondent had a primary education. It was further revealed that 5.1% of the respondents had vocational training while another 5.1% went for adult education and participants with no formal education constituted 7.7%. This showed a reasonable level of literacy in formal education among the farmers. Maddison (2007), Mugula and Mkuna (2016) and Deressa *et al.* (2008) found that experienced

and educated farmers have more skills and knowledge regarding change of climate and coping measures.

Thus, the literacy level of participants significantly affected climate change perception in the current study area. According to Asfaw and Admassie (2004) and Bamire *et al.* (2002) training predisposed agricultural production by enhancing farmer's expertise to produce more output from given resources by strengthening farmer's ability to acquire and analyse information. Ibrahim *et al.* (2015) also stated that farmers' literacy level might affect level of cognizance regarding change of climate and the development of practices for adaptation. Educated farmers respond to climate change risks by making at least few options towards adaptation (Maddison, 2007). Education has important role for awareness in farming because trained people know how to search for information.

Table 8: Frequency distribution of respondents showing their educational qualification

Educational status	Frequency	Percentage (%)
Post-secondary education	86	24.5
Secondary education	104	29.6
Primary education	98	27.9
Vocational training	18	5.1
Adult education	18	5.1
No formal education	27	7.7
Total	351	100.0

Source: used data from the study

4.2.9 Household sizes of respondents

Table 9 shows that 59% of the respondents' household size falls under the range of 3-5, 31.3% had a household size range of 6-8, while household size range of 9-11 amounted to 8.5% and 1.1% represents household size of 12 and above. The finding indicated that there might be improvement in agricultural production especially if family members are fully involved in farming activities. This was similar to the finding of Mugula and Mkuna (2016) who revealed that household with large farm size were more likely to engage in agricultural production, take advantage of high production and are more likely to adapt to climate change.

Table 9: Frequency distribution of the respondents according to their household size

Household size	Frequency	Percentage (%)
3-5	207	59.0
6-8	110	31.3
9- 11	30	8.5
≥12	4	1.1
Total	351	100.0

Source: used data from the study

4.2.10 Occupation of the respondents

Table 10 revealed that farming which is 63.5% was the major occupation of the respondents, 21.9% of the respondents were formally employed, 0.9% participants were traders, 8.2% were self-employed and 5.4% of the respondents were pensioners. The reason why majority of the respondents were engaged in farming might be as a result that they were smallholder farmers with no job other than farming. This was supported by Connolly-Boutin and Smit (2016), and Calzadilla *et al.* (2013) who estimated that farming provided the main livelihood and employment for majority of the population of most developing countries and contributes considerably to national GDP.

Table 10: Frequency distribution of the respondents according to their major occupation

Major occupation	Frequency	Percentage (%)
Farming	223	63.5
Employed formally	77	21.9
Trading	3	0.9
Self employed	29	8.2
Pensioners	19	5.4
Total	351	100.0

Source: used data from the study

4.2.11 Distribution based on source of income of the respondents

Table 11 revealed that farming was the major source of income for majority of the respondents (69.5%) but the remaining 30.5% had other sources of income. This showed that agriculture dominated the study area as a source of living. This corroborate the findings of

Machethe (2004) that farming is the greatest contributor to household income and the most important source of income for "poor" rural households.

Table 11: Frequency distribution of respondents showing their source of income

Source of income	Frequency	Percentage (%)
Yes	244	69.5
No	107	30.5
Total	351	100.0

Source: used data from the study

4.2.12 Distribution based on farmers' farming experience

Table 12 shows the farming experience of the farmers. Majority of the farmers (47.0%) had farming experience of 21 years and above while 26.2% had farming experience range of 6 – 10 years and 19.7% of the respondents had a farming experience ranging between 11 and 15 years. The farmers with less than two years of farming experience constituted 7.1%. The implication of this is that the farmers had knowledge about the farming sector. Ibrahim *et al.* (2015) and Madisson (2007) found that experience impacted positively on farmers' productivity and could perceive climate change earlier.

Table 12: Frequency distribution of the respondents according to farmers year of experience

Year of farming	Frequency	Percentage (%)
<2 years	81	23.1
6-10 years	65	18.5
11-15 years	242	68.9
≥21 years	136	26.8
Total	351	100.0

Source: used data from the study

4.2.13 Categories of crops cultivated by the respondents

Table 13 showed that 85.5% of the respondents had identified cereal crops especially maize as part of the crops they cultivated. It also revealed that majority 63.0% of the farmers cultivated leguminous crops such as beans, soybean and groundnut. The table further revealed that 74.6% of the respondents were into vegetable cultivation. The respondents who planted

different types of fruits was 53% (farmers planting orange were 50.8% while 2.2% were respondents cultivating other types of fruits like mango, bananas, grape etc.) and 9.1% of the respondents identified sugar cane as the other type of crop being cultivated in the study area. This affirm the submission of Altieri *et al.* (2012) that smallholder farmers in Africa produce the majority of grains, legumes, plantain crops and almost all the roots crops consumed.

Table 13: Frequency distribution of the respondents according to the types of crops cultivated

Crops cultivated	Frequency	Percentage (%)
Cereals	301	85.8
Legumes	221	63.0
Vegetables	262	74.6
Fruits	186	53.0
Others (Sugar cane)	32	9.1
Total	351	100.0

Source: used data from the study

4.2.14 Distribution of respondents on the reason of crop cultivation

Majority of the respondents (45.6%) as shown in Table 14 sold surplus of their produce after family consumption, 32.8% of the farmers were producing for consumption while it was also revealed that 22.6% of the respondents were producing commercially. This corroborate the findings of Yaro (2006) that excess production are usually taking to the market by smallholder farming household to sell as a source of income to cater for their financial needs.

Table 14: Frequency distribution of the respondents' showing reasons for crop production

Reasons for cultivating	Frequency	Percentage (%)
Personal consumption	112	31.9
Surplus sold	160	45.6
Commercial purposes	79	22.6
Total	351	100.0

Source: used data from the study

4.2.15 Distribution according to land tenure system

The land tenure system was controlled mostly by communal system of land tenure (72.1%) as seen in Table 15. A total of 17.7% of the land was occupied by the respondents through permission to occupy while 1.1% of the farmers were farming on a leased /rented land and 9.1% of the farmers got their farming land through land reform programmes. Land tenure system can be defined as the rights and institution that governs access to and use of land (Eze *et al.*, 2011). This implied that there might not be restrictions on a privately owned land; and this might enable the farmer to adopt a new method of farming.

Table 15: Frequency distribution of the respondents according to land tenure system

Land tenure	Frequency	Percentage (%)
Communal	253	72.1
Permission to occupy	62	17.7
Renting/Lease	4	1.1
Land reforms	32	9.1
Total	351	100.0

Source: used data from the study

4.2.16 Distribution according to farm owner

Table 16 shows that most farms were owned by individual (46.4%) and 29.9% of the farms were owned by families while farmers' group owned 5.1% of the farmland. In addition, the total farmland that belonged to corporate bodies in the study area constituted 6.8% of the farms and 11.7% belonged to the trust. The indication was that individual farm owner will put the required resources in place for the farming season. This corroborate Koirala *et al.* (2014) who expressed that farmers who lease land for farming are less likely to invest in land improvement activities.

Table 16: Frequency distribution of the respondents showing who owns the farm

Farm owner	Frequency	Percentage (%)
Individual	163	46.4
Family members	105	29.9
Farmers' group	18	5.1
Corporation/Company	24	6.8
Trust	41	11.7
Total	351	100.0

Source: used data from the study

4.2.17 Distribution according to farm operatorship

As presented in Table 17, 46.2% of the respondents managed their own farms while farms managed by family members accounted to be 33.0%. Farmer groups in the study area managed 5.1% of the farms, 6.8% of the farms were also managed by corporate organisation and the trust managed the remaining 8.8% of the farms. The findings show that farmers were managing their farms themselves and this might be due to lack of trust, funds and incentives. This is similar to Otsuka and Hayami (1988) that farms operated by lessor may run inefficiently due to lack of security and absence of sufficient incentives for and returns from investment.

Table 17: Frequency distribution of the respondents according to who operates the farm

Farm operator	Frequency	Percentage (%)
Individual	162	46.2
Family members	116	33.0
Farmers' group	18	5.1
Corporation/Company	24	6.8
Trust	31	8.8
Total	351	100.0

Source: used data from the study

4.2.18 Distribution according to the size of the farm

Majority of the respondents (51.3%) planted on the farm size that ranged between 1 and 5 hectares. The farmers that planted on a farm size that is lesser than 1 hectare constituted 5.4% of the respondents; 16.5% of the respondents cultivated on farm sizes of between 6 and 10

hectares. The total of 1.1% of the participants were farming on a land ranging between 16 and 20 hectares; and the remaining 16.0% were farming on farm sizes greater than 20 hectares. The result shows that farming in the study area is on a small-scale and is in line with DAFF (2012) that smallholder farmers are the drivers of the economies even if their potentials is often not brought forward.

Table 18: Frequency distribution of the respondents showing who manages the farm

Farm size	Frequency	Percentage (%)
<1 hectare	19	5.4
1-5 hectares	180	51.3
6-10 hectares	58	16.5
11-15 hectares	34	9.7
16-20 hectares	4	1.1
>21 hectares	56	16.0
Total	351	100.0

Source: used data from the study

4.2.19 Distribution of respondents based on climate change awareness

Most farmers (66.4%) stated that there was no climate change awareness program in the study area while 33.6% of the farmers claimed there was an awareness program in the study area (Figure 4.1). This shows that farmers had poor access level to extension service. Ibrahim *et al.* (2015) indicated that extension service might limit the information obtained by farmers on agricultural activities and use of innovation systems.

Therefore, it is vital to strengthen non-formal training of farmers on climate change and improved approaches through extension service, which will make it more beneficial, given their main importance in the delivery of this service. Nhemachena (2007) found that an exposure to extension officers capacitated farmers to adjust to climate change.

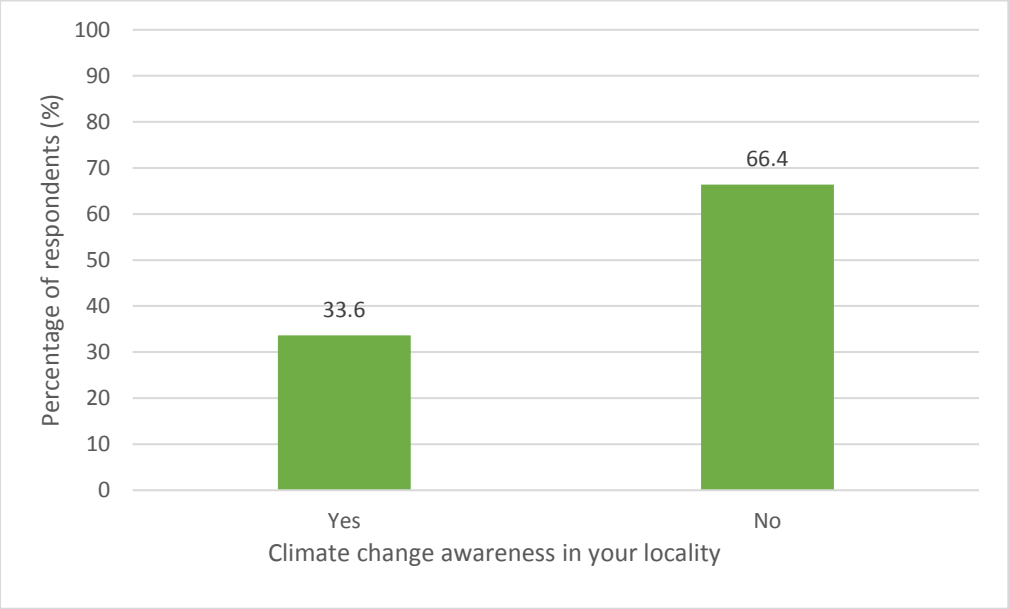

Figure 4.1: Climate change awareness

Source: used data from the study

4.2.20 Distribution of respondents based on climate change information

Figure 4.2 showed that 52.7% of the respondents gained access to information on climate change via different modes available while 47.3% indicated that no information on climate change was received. This implies that slightly more than half of respondents received information regarding climate change but were unable to cope due to either low or no awareness program in the environment. The farmers identified electronic media (radio and television) as the main source of information whereby the extension system that was supposed to disseminate information using a top-bottom approach was not effective. This might make the farmers to conclude that climate change is a natural disaster. Most people perceived climate change because of industrialization and natural causes still (Olayinka *et al.* 2013).

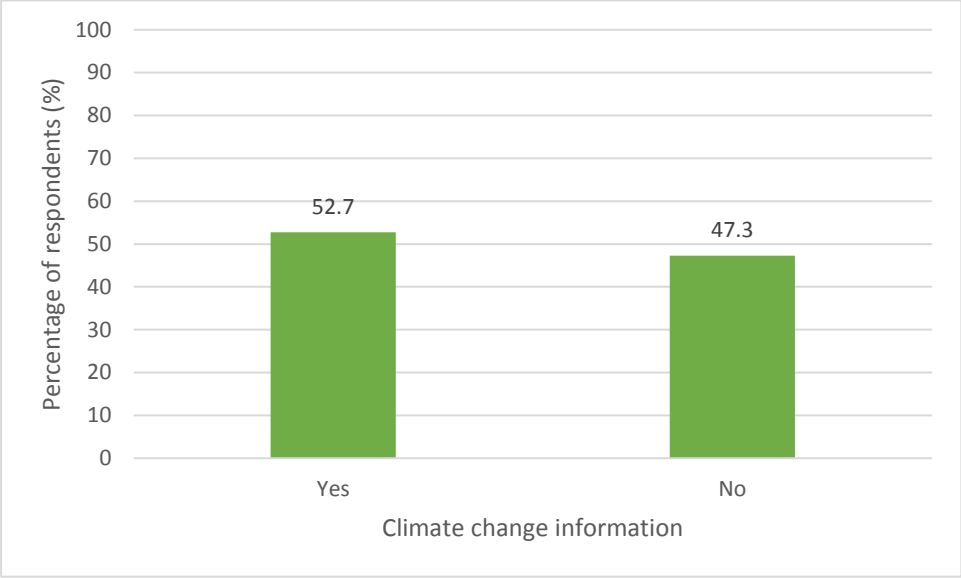

Figure 4.2: Climate change information

Source: used data from the study

4.2.21 Distribution of respondents based on climate change awareness

The farmers were aware of the phenomenon called climate change from different sources but the awareness in the study area as seen by previous figures was not deep rooted in Ehlanzeni district (Figure 4.3). About 76.4% of the respondents knew about climate change while 23.6% were not even aware what was meant by climate change.

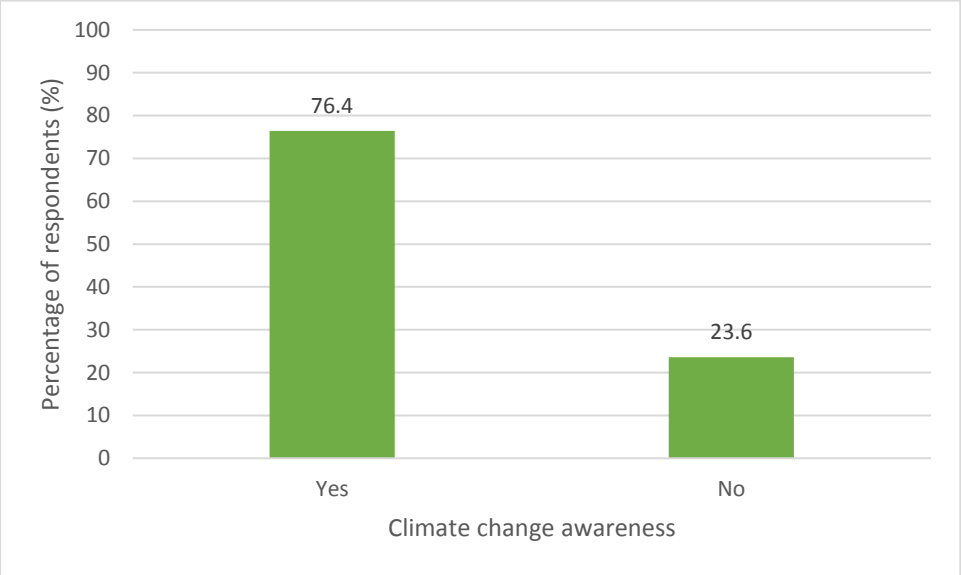

Figure 4.3: Climate change awareness

Source: used data from the study

4.2.22 Distribution of respondents based on source of information about climate change

Table 19 revealed a multiple responses whereby participants that were cognizant of climate change indicated how they know about the phenomenon though they claimed that awareness on change of climate area was poor. The result also showed how important this information contributed to their knowledge of climate change. It was revealed that only 23.1% of the farmers knew about climate change from formal schooling and 11.7% stated that it was important to their knowledge about climate change trend. Majority of the farmers (68.7%) knew about climate change from the media (print and electronic) and this was acknowledged as the contributor to their understanding of climate change. The farmers identified electronic media such as radio and television; likewise print media such as newspaper as a major tool in disseminating ideas on climate change.

Only 13.1% knew about climate change from the extension system and only 5.1% identified extension system as important to their climate change knowledge. The 38.8% stated that they knew from other people like friends and family and 41.7% relied on their own observation of the weather system to improve their knowledge on climate change.

Table 19: Frequency distribution of respondents according to sources of information about climate change

Source of information about climate change	Frequency	Percentage (%)
Formal schooling	62	23.1
Adult education	49	18.3
Media (print and electronic)	184	68.7
Extension system	35	13.1
Other people	104	38.8
Own observation	112	41.7
Total	268	76.4

Source: used data from the study

4.2.23 Distribution based on farmers' general observation on climate change

All of the participants had observed changes in some of the climatic variables (rainfall, temperature, humidity, wind, frost and dew) in the study area, which has been affecting their production in diverse ways. They mentioned temperature and rainfall as the main climatic variables that were changing drastically in recent years and this might be as a result of the

province which had been declared drought susceptible together with six other provinces in South Africa.

Table 20: Frequency distribution of the respondents according to climate change observation

Climatic changes	Frequency	Percentage (%)
Yes	351	100.0
No	0	0.0
Total	351	100.0

Source: used data from the study

4.2.24 Distribution of respondents based on specific changing climatic variables

Table 21 shows multiple responses of the farmers on different climatic variables that were changing in the study area. About 63.8% of the farmers indicated that rainfall intensity was changing. While 93.2% of the farmers identified that, there had been a significant increase in the level of drought intensity. About 85.2% of the farmers disclosed that the temperature level of the area was increasing while 42.7% of the respondents claimed that the study area had experienced strong winds. Similarly 8.3% stated that they has experienced changes in wind situation and 12.8% identified flood as other type of climatic variable that was changing.

The implication of these results was that when there is low density of rainfall combined with increased temperature and strong wind, it will increase the rate of evaporation and this will lead to drought. This is an implication that made the farmer to identify drought as the most climatic change variable in the study area. In support, Nhemachena *et al.* (2014) showed that Southern Africa had recently been experiencing recurrent droughts. According to SAWS (2015) South African government and South African Weather Services have declared Mpumalanga province as one of the areas severely affected by drought in the country.

Table 21: Frequency distribution of respondents according to changing climatic variables

Changing climatic variables	Frequency	Percentage (%)
Rainfall	224	63.8
Drought	327	93.2
Increased temperature	299	85.2
Strong wind	150	42.7
No wind	29	8.3
Others (flood)	45	12.8

Source: used data from the study

4.2.25 Distribution based on perception on long-term rainfall

Table 22 shows that majority of the farmers (84.6%) identified that rainfall would decrease in the study area in the long run while 15.4% indicated that there would be an increase in rainfall in the long run. There is a comparison between the result and other studies conducted in other semi-arid environments likewise other parts of Africa (Moyo *et al.,* 2012; Nyanga *et al.,* 2011; Rao *et al.,* 2011; Slegers 2008; Maddison 2007).

Farmers' perceptions of rainfall in the study area in the end reported changes in rainfall (especially more erratic as well as reduced amounts) that might adversely affect crop and livestock production (Nhemachena *et al.,* 2014; Moyo *et al.,* 2012). Maddison (2007) also found that farmers opined to increase in temperatures while rainfall will decrease.

Table 22: Frequency distribution of respondents according to perceptions on long term rainfall changes

Long term rainfall perceptions	Frequency	Percentage (%)
Increase in rainfall	54	15.4
Decrease in rainfall	297	84.6
Total	351	100.0

Source: used data from the study

4.2.26 Distribution based on perception on temperature

Table 23 reveals that 79.5% of the farmers pinpointed an increase in temperature in the end while 20.5% maintained that there will be a decrease in temperature in the long run. This affirmed the study of Maddison (2007) who enunciated that farmers maintained increase in temperature whilst rainfall will decrease.

Table 23: Frequency distribution according to perceptions on long term temperature changes

Long term temperature perceptions	Frequency	Percentage (%)
Increase in temperature	279	79.5
Decrease in temperature	72	20.5
Total	351	100.0

Source: used data from the study

4.2.27 Distribution based on how climate change affects crop production

It was revealed in Table 24 that climate change has affected crop production. All farmers did not indicate that their crop production output was improved by climate change. Most respondents (80.1%) affirmed that their crop production level has been reduced and 19.9% confirmed that they experienced no production since climate change was affecting the farming activities.

These findings corroborated with the statement of USDA (2007) that change of climate has both optimistic and damaging impacts on agriculture. Food scarcity could be a consequence of hostile effects if no prompt efforts were tabled to control these challenges. Akinnagbe *et al.* (2014) specified that crop yields were affected by factors linked to climate change such as rainfall, temperature, extreme weather events, CO_2 concentration in the atmosphere and climate variability.

Table 24: Frequency distribution of respondents according to how climate change is affecting crop production

How climate change affect crop	Frequency	Percentage (%)
Decreased production	281	80.1
No production	70	19.9
Total	351	100.0

Source: used data from the study

4.2.28 Distribution of respondents based on impacts of climate change on livelihoods

Table 25 indicated multiple responses on how livelihoods had been affected by climate change. About 81.8% of the farmers indicated that climate change increased their socio-economic problems. The 75.8% expressed that reduction in income was another way climate change has been affecting their livelihood and 71.2% stated that changes in climatic variables

increased unemployment rate in the study area. The 50.4% said that climate change reduced cultivated lands; 49.9% identified reduced cultivated practices as one of the negative effects of climate change on livelihoods in the study area but 8.5% stated that climate change increased their cultivated practices. The finding of the study supported Nhemachena *et al.* (2014) who stated that climate change have an adverse contribution on the livelihood sources, which are majorly agricultural-based.

Table 25: Frequency distribution according to climate change impacts on livelihood

Climate change impact on livelihood	Frequency	Percentage (%)
Increased socio economic problems	287	81.8
Reduced income	266	75.8
Increased unemployment	250	71.2
Reduced cultivated lands	177	50.4
Reduced cultivated practices	175	49.9
Increased cultivated practices	30	8.5
Total	1185	100.0

Source: used data from the study

4.2.29 Distribution of respondents based on impacts of climate change on agricultural production

Multiple responses of the respondents on effects of climate change on agriculture productivity are reflected on Table 26. Most farmers (86.3%) indicated that climate change reduced crop yields while only 6.8% indicated that crop yield increased with the impact of climate change. Furthermore, about 87.2% affirmed that climate change had increased diseases affecting crop production in the area in addition to the 61.3% that claimed changes in climatic variables led to reduction in land fertility. This validates Benhin (2006) that climate change impacts on agricultural production may be different from different farming systems. The small scale crop farmers will be severely affected and their net revenues are expected to be 90% reduced by 2100. Therefore, increased climate changes might be detrimental to crop agriculture in the study area.

Table 26: Frequency distribution of respondents according to climate change impacts on agricultural production

Climate change impact on agricultural production	Frequency	Percentage (%)
Reduce land fertility	215	61.3
Increase crop yield	24	6.8
Reduce crop yield	303	86.3
Increase crop disease	306	87.2
Total	848	100.0

Source: used data from the study

4.2.30 Distribution based on impacts of climate change on food security

Multiple responses of the participants on effects of climate change on food security is presented in Table 27. All farmers stated that climate change had increased the price of food. About 72.4% indicated that climate change was reducing the household income as 58.7% stated that food scarcity was caused by climate change. About 62.7% of the farmers revealed that climate change had caused lack of local markets. The climate change stressors can lead to seasonal crop failure and long term production problems resulting in food insecurity due to a reduction in the availability of food. Codjoe and Owusu (2011) and Yaro (2006) further stated that low crop yield affect people access to food since household usually sell surplus at the market as a source of income.

Table 27: Frequency distribution according to climate change impacts on agricultural production

Climate change impact on food security	*Frequency	Percentage (%)
Reduce income	254	72.4
Food scarcity	206	58.7
Increase food price	351	100.0
Lack of local market	220	62.7
Total	1031	100.0

Source: used data from the study

4.2.31 Distribution of respondents based on adaptation to climate change

According to Figure 4.4, 71.5% of participants were unable to cope with climate change while only 28.5% were able to acclimatize with the negative effects of climate change. This might be due to many reasons like not being aware of climate change, lack of access to extension officers and lack of financial support. James *et al.* (2013) found many years of experience in farming, higher education, access to financial support and extension service are important factors of coping with climate change.

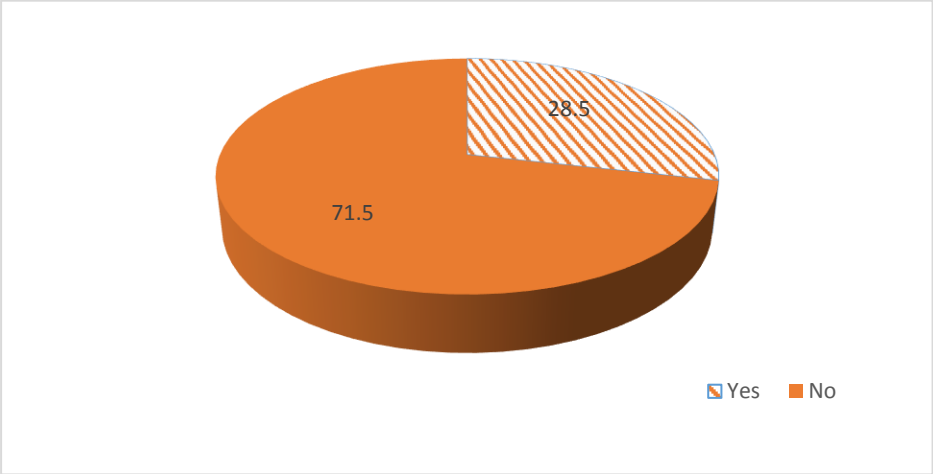

Figure 4.4: Climate change adaptation

Source: used data from the study

4.2.32 Distribution of respondents based on perceived adaptation option

About 38.2% described multi-cropping as an adaptation option to climate change problems while 33.3% stated that planting of different crop varieties would help farmers to cope. Another coping strategy revealed by the farmers was using different planting dates, which was identified by 29.2% of the sampled size. This is supported by the results of James *et al.* (2013) that farmers in Sub-Saharan Africa were cognizant of changes in rainfall patterns and temperature. Thus, they adopted crop diversification, changing planting and harvesting dates and planting of different crops to respond to the changing rainfall patterns.

Moreover, 4.3% of the respondents identified moving to different farms as a solution to climate change peril and 34.2% described crop rotation as a solution. About 4.8% revealed changing from crop farming to livestock farming as a solution to the risk. In addition, 33.0% stated that improve irrigation system will help adjust to the problems of climate change, 11.7% identified mixed farming method as an adaptation strategy. Furthermore, 27.1% pointed out to changing to the use of chemicals, fertilizer and pesticide instead of organic agriculture;

likewise, 36.8% of the farmers said increase in water conservation will help to reduce the threat climate change pose to agriculture.

About 34.2% stated soil conservation as an adaptation strategy and 19.1% describe insurance as an approach to manage climate change problems militating against them. In addition, 6.0% resolved to subsidies while 35.0% indicated prayers as a solution to climate change problem and 8.5% of the respondents said there is no perceived adaptation strategy to climate change problems in the study area.

Table 28: Frequency distribution according to perceived adaptation option

Peceived adaptation	Frequency	Percentage (%)
Multi cropping	134	38.2
Planting of different crop varieties	117	33.3
Crop diversification	105	29.9
Use different planting dates	126	35.9
Move to different farm land	15	4.3
Crop rotation	120	34.2
Change from crop farming to livestock farming	17	4.8
Change to mixed farming	41	11.7
Increase irrigation system	116	33.0
Change to use of fertilizers, chemicals and pesticides	95	27.1
Improve water conservation	129	36.8
Soil conservation	120	34.2
Using insurance	67	19.1
Subsidies	21	6.0
Using prayers	123	35.0
No perceived adaptation	30	8.5
Total	351	100.0

Source: used data from the study

4.2.33 Distribution of respondents based on problems of embracing adaptation measures

The Table 29, revealed a multiple responses why some of the respondents did not cope with climate change. Majority of the farmers 60.2% indicated that lack of technical-know-how was a major problem of not adopting adaptation measures; while 54.4% of the farmers did not know what to do about climate change. About 28.8% identified distance to weather stations as

another problem of not adopting adaptation measures while 27.1% of the farmers revealed lack of money as a problem. Likewise, 11.6% stated lack of information as reason they did not adopt an adaption measure. Also 2.8% of the farmers said adaptation was not applicable.

Table 29: Frequency distribution according to problems of adopting adaptation measures

Problems of not adapting to climate change	*Frequency	Percentage (%)
Lack of information	29	11.6
Lack of money	68	27.1
Not aware of climate change	59	23.5
Do not know what to do	137	54.6
Lack of technical-know-how	152	60.2
Distance to weather station	72	28.7
Not applicable	7	2.8
Total	251	100.0

Source: used data from the study

4.2.34 Descriptive statistics of variables used in the logit model analysis

The dependent and independent variables used in the logit model are presented in Table 30.

Table 30: Discriptive statistics of variables used in logit analysis

Variables	Categories	Minimum	Maximum	Mean	S D	Variance
Awareness of Climate Change yes = 1, no = 2	Dichotomous	1	2	1.66	0.473	0.224
Age <18 = 1 19-35 = 2, 36-45 = 3 46-55 = 4, ≥56 = 5	Years	2	5	3.88	0.995	0.989
Gender male = 1, female = 2	Dichotomous	1	2	1.28	0.449	0.202
Marital status single = 1 married = 2 divorced = 3 widowed = 4 seperated=5	Classified	1	5	2.07	0.852	0.727
Educational status university = 1 college = 2 advanced level = 3 high school = 4 some high school = 5 complete primary = 6 some primary = 7 vocational = 8 some vocational = 9 adult education = 10 no formal education = 11	Classified	1	11	5.44	2.744	7.528
Household size	Continuous	3	14	5.54	1.892	3.580
Major occupation farming = 1, formally employed = 2, trading = 3, self employed = 4, business = 5, pension = 6, no occupation = 7	Classified	1	6	1.77	1.365	1.864
Source of income, yes = 1, no = 2	Dichotomous	1	2	1.30	0.461	0.213
Land tenure system private = 1 communal = 2, pto = 3, renting = 4, others = 5	Classified	2	5	2.47	0.906	0.821
Who owns the farm, individual = 1 family members = 2, farmers' group = 3 corporation = 4, trust = 5, other = 6	Classified	1	5	2.07	1.357	1.840
Who manages the farm individual = 1 family members = 2, farmers' group = 3 corporation = 4, trust = 5, other = 6	Classified	1	5	1.99	1.259	1.8840
Size of the farm <1 hectare = 1, 1 – 5 hectares = 2, 6 – 10 hectares = 3, 11 – 15 hectares = 4, 16 – 20 hectares = 5 >20 hectares = 6	Classified	1	6	2.98	1.521	2.314
CC information yes = 1, no = 2	Dichotomous	1	2	1.47	0.500	0.250
CC awareness yes = 1, no = 2	Dichotomous	1	2	1.24	0.426	0.181
Perception of rainfall increase in rainfall = 1, decrease in rainfall = 2, rainfall not changed = 3 no observed changes = 4, other = 5	Categorised	1	2	1.85	0.361	0.131
Perception of temperature increase in temperature = 1, decrease in temperature = 2, temperature not changed = 3, no observed changes = 4, other = 5	Categorised	1	2	1.21	0.404	0.164
Effects of climate change on crops increase production = 1, no change in production = 2, decreased production = 3, no production = 4, other = 5	Classified	3	4	3.20	0.400	0.160
Climate change adaptation yes = 1, no = 2	Dichotomous	1	2	1.72	0.452	0.204

Source: used data from the study

4.3 Results and discussion of the inferential analysis using the logit model

This section discussed the results of the logit model that was used to analyse factors influencing the farmers awareness of climate change which will help them to be conscious of the effects (positive or negative) of this phenomenon on crop production in the current study area. The results showed that 76.4% were cognizant of climate change while 23.6% were not aware. This might have been influenced by many factors, including socio-economic and demographic factors. The logit model was, therefore, used to determine these factors which influenced the awareness among the farmers as presented in the Table 4.3. There could be improvement in farmers knowledge of climate change if these factors are addressed. The model summary of the results showed that optimal solution was found. The highly significant chi-square test, indicated the Pearson model, goodness-of-fit test. Four out of the eleven independent variables had statistically significant influence on farmers awareness of climate change. The results presented in Table 4.3 show that there was significant influence of the age of the farmers, who managed the farm, who owned the farm and land tenure system on farmers' awareness of climate change.

Age is an important variable associated with climate change awareness. This cuts across all age categories in everyday undertakings. The results of this study showed that age has a statistically significant negative relationship (P=0.019) with climate change awareness of the farmers. This means that, age is inversely related to awareness of climate change of a farmer with all other factors held constant (Featherstone and Godwin 1993; Gould *et al.* 1989). Thus increase in farmer's age reduces his awareness of climate change with all other factors held constant.

The Logit coefficient estimate regarding land tenure system (Table 4.3) was negative and statistically significant (P=0.062), indicating a negative correlation between land tenure system and climate change awareness of the farmers with other factors held constant. This means that the types of tenure such as communal, renting and others reduces the awareness of climate change. Thus, private and owner-operator form of land tenure improves climate change awareness. This may be due to participants took cognizance of climate change when they were farming on a privately owned land compared to the other types of land tenure.

The results in Table 4.3 showed the Logit coefficient estimate of who managed the farm had negative significance (P=0.036) on farmers' level of awareness to climate change with other factors held constant. This may be due to the fact that a farm managed by corporation or company or trust might not care if the farmers working for them are informed while company might have put measures to mitigate or adapt to climate change. Likewise, the

managers might believe that the workers doing the bunch of the jobs are doing it to earn salary so it might not be necessary to educate them on climate change phenomenon.

The logit coefficient estimates results associated with who owned the farm and farmers' cognizance to change of climate was positive and significant (P=0.072) This indicates that climate change awareness increases as you move from individual ownership through company ownership and trust type of ownership with all other factors held constant. This might be because each type of the aforementioned ownerships will strive hard to have a good produce at the end of each planting season, so will have to broaden their knowledge on every area that will help them to achieve this aim which climate change is part. This will make them to seek more knowledge on the phenomenon and mitigating/adaptation methods involved. Ownership of the farm has proved to bring a sense of responsibility to farm owners.

Table 31: Parameter estimates of logit regression of awareness of climate change among farmers in the study area

Parameter	Estimate	SE	Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Age of the respondents	-.057	.024	-2.350	.019**	-.104	-.009
Gender of the respondents	.064	.046	1.385	.166	-.027	.155
Educational status	.011	.008	1.364	.173	-.005	.027
Household size of the respondents	.000	.012	.009	.993	-.024	.024
Climate change information	-.056	.052	-1.061	.289	-.158	.047
Land tenure system	-.064	.034	-1.865	.062***	-.131	.003
Major source of income	-.046	.043	-1.082	.279	-.131	.038
Size of the farm	.036	.025	1.462	.144	-.012	.084
Who manages the farm	-.056	.027	-2.096	.036**	-.109	-.004
Who owns the farm	.045	.025	1.796	.072***	-.004	.095
Adaptation to climate change	.071	.052	1.358	.174	-.031	.173
Intercept	-2.722	.116	-23.455	.000	-2.838	-2.606

LOGIT model: LOG (p/(1-p)) = Intercept + BX. *** Significant level at 10%. **Significant level at 5%.

Source: used data from this study.

Chi-Square Tests

	Chi-Square	df	Sig.
LOGIT Pearson Goodness-of-Fit Test	2806.080	339	.000

Convergence information of the variables

4.4 Comparing farmers' perceptions and empirical rainfall and temperature evidence

According to Nhemachena (2014), various models of climate change for Southern Africa indicated that this region will face intensified encounters of climate change. In most parts of Southern African region, it was predicted that there will be declines in rainfall and augmented rain variability (Nhemachena, 2014; IPCC, 2007; Tadross *et al.*, 2005). Nhemachena (2014) further explained that Southern Africa has lately experienced frequent droughts. Moyo *et al.* (2012) indicated that these experiences together with other extreme climatic happenings were anticipated to carry on. In summary the region is expected to experience more warming, drying and other harsh climate change conditions.

The trend (Figure 4.5) for the past three years shows that there has been a significant decrease in annual rainfall, which is consistent with the empirical models for Southern Africa region that there will be decreases in rainfall (IPCC, 2007; Nhemachena, 2014). It implies that over a long-term period climate data fail to show the evidence perceived by farmers. Therefore, this result showed that farmers can accurately perceive change and climate variability and impacts on agriculture and livelihoods for short time period.

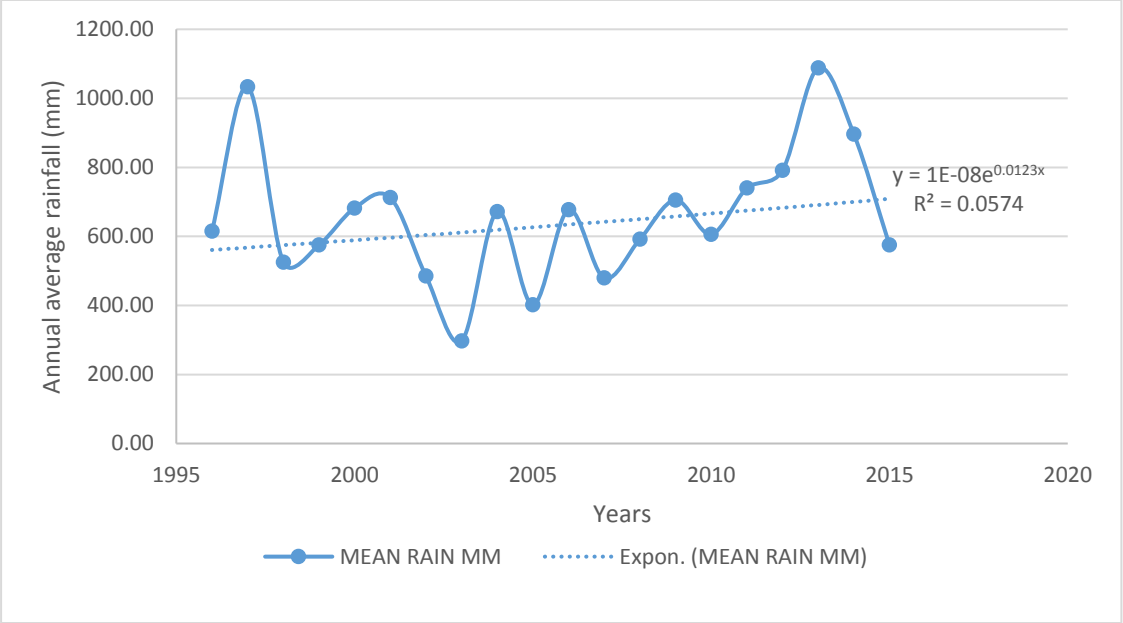

Figure 4.5: Mean rainfall of Lowveld areas

Source: South African Weather Services (2016)

Furthermore, farmers' perceptions on temperature were generally comparable to the temperature data provided by the South African Weather Services for the study area with the trend line that showed a rising movement. This indicated that temperature has been increasing in the study area between the periods of 1996 - 2015. Thus, the results for perceptions on temperature were in agreement with trends in observed temperatures. This indicated a clear increase in temperature but temperature increase in the last three years has moved to an extreme. This caused drought in the study area, which is accords with the projection for the Southern Africa region that has lately been facing frequent droughts caused by reducing rainfall and rise in temperature.

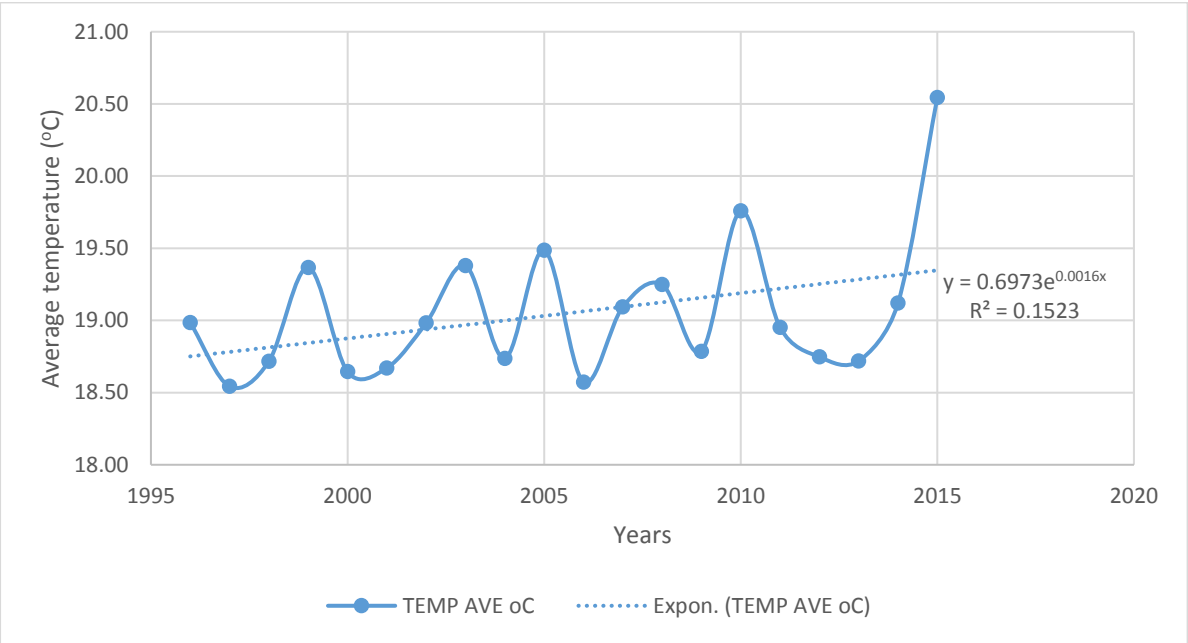

Figure 4.6: Mean temperature of Lowveld areas

Source: South African Weather Services (2016)

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the major findings

The study investigated the perceived effects regarding change of climate on crop production in the study area. Farmers' socio-economic characteristics were studied in order to investigate, their perception about climate change and their level of awareness on the phenomenon.

Majority of the respondents (33.9%) were found to be 56 years of age and above. Farming is the major occupation of most of the respondents 63.5% while 69.5% of them revealed farming as their income source. Most farmers owned the farm land (46.4%) but only 46.2% manage the farm themselves.

All the respondents pointed out that they had perceived variations in either one or more climatic variables in their locality. However, 84.6% identified that rainfall is decreasing compared to the 15.4% that indicated that rainfall was increasing, similarly, 79.5% pin point increase in temperature.

In terms of climate change affecting crop production, it was revealed that majority 80.1% of the farmers had observed their production decreased while 19.9% had no production in recent times and this has been affecting the farmers' livelihood in increasing their socio-economic problems, reduction in farmers' income and increased unemployment. Furthermore, the impact of climate change on the livelihood of the farmers in the study area include reduction in cultivated lands and reduction in cultivated practices.

Majority of the farmers 76.4% stated that they were cognizant of climate change with respect to 23.6% that were not acquainted with the phenomenon. Almost thirty-seven percentage (36.6%) of the respondents confirmed that climate change cognizance is available in the study area while 66.4% claimed there was no climate change awareness. This might be the major reason the effect of climate change is so high in the study area.

From the Logit model, the coefficient of age was significant at 5% however the coefficients of land tenure system, who managed the farm and the owner of the farm were also significant at 10%, 5% and 10% respectively when considering farmers' awareness of climate change.

5.2 Conclusions

Climate change has been a concern in South Africa and there are discussions to determine strategies to deal with the challenges from climate change but this cannot be achieved if people's perceptions and opinions do not count. This is why the study was conducted to evaluate farmers' perception regarding change of climate on crop production and their cognizance level. The main challenge was education; awareness and sensitivity to climate change are falling behind in South Africa. Thus, most Mpumalanga province farmers have to be educated about climate change so that they can contribute towards the adaptive capacity and reduce vulnerability.

The major outcomes of the study was that majority of farmers perceived temperature increase accompanied by a decline in annual rainfall which was corroborated by the climatic variable data sourced from South African Weather Services. The study observed that most farmers were cognizant of climate change but an appreciable number of them were not aware about the happenings of climate in their locality.

The study also revealed that age of the farmers less directly influenced their awareness level. The perceived impacts that changing climate has on crop production as stated by farmers includes reduction in land fertility, decrease in crop yield, crop diseases become more intense and livestock production decreases. The existence of impacts related to climate change on crop production in the current study area might be confirmed through this study.

5.3 Recommendations

The following recommendations were made and could be considered by the provincial government and other sectors involved in matters related to changing climate. These recommendations could go a long way in developing policies to survive the effects of climate change variables on crop production of the current study area centred on the farmers' perception.

1. The farmers' age should always be considered when awareness programme is planned. Awareness programme should be put in place on the farm irrespective of the type of farm ownership. However, who manages the farm should be considered in such programmes' implementation. This will assist to alleviate/deal with climate change incidences and decrease government budget on adaptation strategies because farmers would have put down some efforts in coping to the menace of climate change.

2. Farmers' perception of climate change should be appraised whenever agricultural programs are designed and executed. Similarly, programs should be planned such that farmers understand the phenomenon climate change better. This might assist in gaining participation from farmers when adaptation programs are applied. Farmers perceived climate change in a form of decreasing annual rainfall, increasing temperature and low humidity which implies that programmes must consider perceived changes in climatic variables.

3. Farmers should be educated about climate change because the study discovered that climate change information was lagging behind in the study area. Therefore, a crucial dissemination of information to understand this phenomenon better and the effects it has on farming production and livelihood is recommended. This can be achieved by education that will lead to improvement in the cognizance level of the phenomenon.

4. An agricultural programme should be established both on and off the farm for farmers in the study area to teach them about climate change and its menace. The communities that are most predisposed to this phenomenon must be provided with utmost assistance including education by government through policies.

REFERENCES

Adebayo, A.A., and Tukur, A.L. (2003). Farmers' perception of environmental problems in Adamawa state, Nigeria. *African Journal of Environmental management*. Vol. 1, pp 52-61.

Adger, W.N., Saleemul, H., Brown, K., Conway, D. and Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies,* 3; pp 179-195.

Akiyode, O. and Daramola, A. (2011). Climate change and socio-economic development in Africa. *Peace and Conflict.* University for Peace.

Altieri, M.A., Fernando, R., Funes-Monzote P.P. (2012). Agro ecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agronomy for Sustainable Development,* 32: 1-3.

Anderson, J. and Bausch, C. (2006). Climate change and natural disasters: Scientific evidence of a possible relation between recent natural disasters and climate change. IPOL/A/ENVI/2006-19. PE 373.583. Retrieved July 30th, 2015.

Aphunu, A. and Nwabeze, G.O. (2012). Fish farmers' perception of climate change impact on fish production in Delta state, Nigeria. *Journal of Agricultural Extension* Vol. 16. No. 2. pp 1-13.

Asfaw, A. and Admasssie, A. (2004). The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia. *The Journal of the International Association of Agricultural Economists,* Vol. 30. pp 215-228.

Baede, A. P. M., E. Ahlonsou, Y. Ding, and D. Schimel, 2001: The climate system: An overview. In: Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [J. T. Houghton, Y. Ding, D. J. Griggs, M. Noquer, P. J. van der Linden, X. Dai, K. Maskell and C. A. Johnson (eds.)].

Bamire, A.S., Fabiyi, Y.L. and Manyong V.M. (2002). Adoption pattern of fertiliser technology among farmers in the ecological zones of South-Western Nigeria: A Tobit analysis. *Australian Journal of Agricultural Research,* Vol. 53. pp 901-910.

Bayard, B., Jolly, C.M., and Shannon, D.A. (2007). The economics of adoption and management of alley cropping in Haiti. *Journal of Environmental Management,* Vol. 84: pp 62-70

Benhin, J.K.A. (2006). Climate change and South Africa agriculture: Impacts and adaptation options. *CEEPA Discussion Paper* No 21. CEEPA, University of Pretoria, South Africa.

Binswanger-Mkhize H.P. (2014). From failure to success in South African land reform. *African Journal of Agricultural and Resource Economics,* Vol. 9, No. 4. pp 253-269.

Bryan, E., Deressa, T.T., Gbetibuouo, G.A. and Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa options and constraints. *Environmental Science and Policy,* Vol. 12. pp 413-426

Building Nigeria's Response to Climate Change, BNRCC. (2008). The recent global and local action on climate change. *Annual workshop of Nigerian Environmental Study Team (NEST), held at Hotel Millennium, Abuja, Nigeria, between 8th-9th October, 2008.*

Calzadilla, A., Rehdanz, K., Betts, R., Falloon, P., Wiltshire, A. and Tol, R.S.J. (2013). Climate change impacts on global agriculture. *Climatic Change,* Vol. 120, pp 357-374.

Codjoe, S.N.A. and Owusu G. (2011). Climate change/variability and food systems: evidence from the Afram Plains, Ghana. *Regional Environmental Change,* Vol. 11, Issue 4, pp 753-765.

Connolly-Boutin, L. and Smit, B. (2016). Climate change, food security and livelihoods in sub-Saharan Africa. *Regional Environmental Change,* Vol 16, No. 2; pp 385-399

Creswell, J.W. (2014). *Research designs: Qualitative, quantitative and mixed methods approaches (4th Edition).* Sage publication, Thousand Oaks, California, USA.

DAFF, Department of Agriculture, Forestry and Fisheries (2012). A framework for the development of smallholder farmers through cooperative development.

De La Torre, A., Fejnzylber, P. and Nash, J. (2009). *Low carbon, high growth. Latin American responses to climate change.* World Bank Latin American and Caribbean Studies.

Deressa, T., Hassan, R. and Poonyth, D. (2005). Measuring the impact of climate change on South African agriculture: The case of sugarcane growing regions. *Agrekon.* Vol 44, No 4.

Deressa, T., Hassan, R.M., Alemu, T., Yesuf, M. and Ringler, C. (2008). Analysing the determinants of farmers' choice adaptation methods and perceptions of climate change in the Nile Basin of the Ethiopia. *IFPRI Discussion Paper 00798.* September, 2008.

De Salvo, M., Begallio, B., and Signorello, G. (2013). Measuring the effect of climate change on agriculture: A literature review of analytical review of analytical models. *Journal of Development and Agricultural Economics,* Vol. **5** No. 12; pp 499-509.

De vos, A.S., Strydom, H., Fouche, C.B. and Delport, C.S.L. (2015). *Research at grassroots: For the social sciences and human service professions.* (4th edition). Van Schaik Publishers, South Africa

Environpedia (2016). Air/Climate/Weather pollution/ Ozone/ Sustainability. From https://www.environpedia.org.uk/climate_change/climate_system.php Retrieved February, 3rd, 2016.

Fischer, G., Shali, M., Francesco, N. and Vanvelhizen, H. (2005). Socio-economic and climate change impacts on agriculture: An integrated assessment, 1990-2080. *Philosophical Transactions of the Royal Society.* 360: 2067-2083

Food and Agriculture Organisation, FAO. (2010). Climate change adaptation and mitigation: New initiatives and update on agriculture, forestry and fisheries proceedings: *Thirtieth FAO regional conference for the Near East. December 4th-8th, 2010, Khartoum, the Republic of Sudan.*

Fosu-Mensah, B.Y., Vlek, P.L.G. and MacCarthy, D.S. (2007). Farmers' perception and adaptation to climate change: A case study of Sekyedumase district in Ghana. *Environment Development and Sustainability.* Volume 14 pp 495-505.

Galindo, L.M., Reyes, O., and Alatorre, J.E. (2015). Climate change, irrigation and agricultural activities in Mexico: A Ricardian analysis with panel data. *Journal of Development and Agricultural Economics.* Vol. 7(7), pp 262-273. Doi:10.5897/JDAE2015.0650.

Gbetibouo, G.A., and Hassan, R.M. (2005). Measuring the economic impact of climate change on major South African field crops: A Ricardian approach. *Global and Planetary Change* Vol. 47, pp 143-152.

Getu, A. (2014). The effects of climate change on livestock production, current situation and future consideration. *African Journal of Animal Production and Husbandry,* Vol. 1(3), pp 029-034.

Golafshani, N. (2003). *Understanding reliability and validity in qualitative research. The Qualitative Report.* (Vol. 8. No. 4, pp 597-607) Available at:http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf. Retrieved July 30th, 2015.

Gould, B.W., Saupe, W.E. and Klemme, R.M. (1989). Conservation tillage: The role of farm and operator characteristics and the perception of soil erosion. *Land Economics* Vol. 65, pp 167-182.

Gould, E.A. and Higgs, S. (2009). Impact of climate change and other factors on emerging arbovirus diseases. *Transaction of the Royal Society of Tropical Medicine and Hygiene,* Vol. 103; pp 109-121.

Haines, A., and Patz, J.A. (2004). Health effects of climate change. *Journal of the American Medical Association*. Vol. 291; pp 99-103. Doi: 10.1001/jama.291.1.99.

Hayo, M.G., Van der Werf and Jean Petit (2002). Evaluation of the environmental impact of agriculture at the farm level: a comparison of 12 indicator-based methods. *Agriculture, Ecosystems and Environment.* Vol. 93. pp 131-145.

Howden, M., Jean – Francois, S., Tubeiello, F.N., Chhetri, N., Dunlop, M., and Meinke, H. (2007). Agriculture and climate change. Available at: www.pnas.org/cgi/content/full/0701890104/Dci Vol. 104 No. 50; pp19691-19696. Retrieved December 10th, 2015

Ibrahim, S.B., Ayinde, I.A. and Arowolo, A.O. (2015). Analysis of arable crop farmers' awareness to causes and effects of climate change in South Western Nigeria. *International journal of Social Economics,* Vol. 42, No 7. pp 614-628.

Idowu, A.A., Ayoola, S.O., Opele, A.I. and Ikenweiwe N.B. (2011). Impact of climate change in Nigeria. *Iranica Journal of Energy and Environment,* Vol. 2, No. 2; pp 145-152

Intergovernmental Panel on Climate Change, IPCC. (2001). *Climate change: Impacts, Adaptation and Vulnerability.* United Kingdom, Cambridge University press.

Intergovernmental Panel on Climate Change, IPCC. (2007). Climate change: Impacts, adaptation and vulnerability. *Working Group II Contribution to the Fourth Assessment Report of IPCC.* United Kingdom, Cambridge University press.

Ishumael, S. (2013). An investigation of communal farmers' livelihoods and climate change challenges and opportunities in Makonde rural district of Zimbabwe. Doctor of literature and Philosophy research thesis. Department of Environmental Science. University of South Africa.

James, S.J., Zibanani, K. and Francis, N.O. (2013). Farmers' perceptions and adaptations to climate change in sub-Saharan Africa: A synthesis of empirical studies and implications

for public policy in Africa agriculture. *Journal of Agricultural Science*, Vol. 5. No. 4. pp 121-135.

Johnson, D.L., Ambrose, S.H., Bassett T.J., Bowen, M.L., Crummey, D.E., Isaaoson, J.S., Johnson, D.N, Lamb, P., Saul, M. and Winter-Nelson, A.E. (1997). Meanings of environmental terms. *Journal of Environmental Quality*, Vol. 26. pp. 581-589.

Johnson, R.B., Onwuegbuzie, A.J. and Turner, L.A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, Vol. 1, No. 2. 112-133.

Jokastah, W.K., Walter, L.F. and David, H. (2013). Smallholder farmers' perception of the impacts of climate change and variability on rain-fed agricultural practices in semi-arid and sub-humid regions of Kenya. *Journal of Environment and Earth Science*, Vol. 3, No. 7. pp 19-141.

Koirala, K.H., Mishra, A.K. and Mohanty, S. (2014). Impactof land ownership on productivity and efficiency of rice farmers: A simulated maximum likelihood approach. Paper prepared for presentation at the Agricultural and Applied Economics Association Annual Meeting, Minneapolis, MN, 27th – 29th July, 2014.

Kumar, R. (2005). *Research Methodology, a step by step guide for beginners.* Pearson education, Australia.

Low, A.B. and Rebelo, A.G. (1996). Vegetation of South Africa, Lesotho and Swaziland: A companion to the vegetation map of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

Machethe, C.L. (2004). Agriculture and poverty in South Africa: Can agriculture reduce poverty? Department of Agricultural Economics, Extension and Rural Development and Postgraduate School of Agriculture and Rural Development. University of Pretoria.

Maddison, D. (2007). The perception of and adaptation to climate change in Africa. *Policy Research Working Paper 4308.*

Mandleni, B. (2011). Impact of climate change and adaptation on cattle and sheep farming in the Eastern Cape province of South Africa. PhD thesis. Department of Environmental Science. University of South Africa.

Maponya, P. (2010). Climate change and agricultural production in Limpopo province, South Africa: Impact and Adaptation options. PhD thesis. Department of Environmental Science. University of South Africa.

Maponya, P., and Mpandeli, S. (2012). Climate change and agricultural production in South Africa: Impacts and adaptation options. *Journal of Agricultural Science,* Vol. 4, No. 10. pp 48-60.

Medugu, N.I. (2008). Nigeria: Climate change – A threat to the country's development. Retrieved July14th, 2015 from http://www.allafrica.com/Nigeria/

Mendelsohn, R., Nordhaus, W., and Shaw, D. (1994). The impact of global warming on agriculture: A Ricardian analysis. *American Economic Review,* Vol. 84, No. 4; pp 753-771.

Mendelsohn, R. and Dinnar, A. (1999). Climate change, Agriculture and developing countries: Does adaptation matter? *The World Bank Research Observer,* Vol. 14(2): 277-293.

Mendelsohn, R., Dinar, A., and Sanghi, A. (2001). The effect of development on the climate sensitivity of agriculture.

Mendelsohn, R., and Seo S. N. (2007).Changing farm types and irrigation as an adaptation to climate change in Latin American agriculture. *Policy Research Series Working Paper, World Bank.*

Moyo, M., Mvumi, B.M., Kunekweguta, M., Mazvimavi, K., Craufurd, P. and Dorward, P. (2012). Farmer perceptions on climate change and variability in semi-arid Zimbabwe in relation to climatology evidence. *African Crop Science journal,* Vol. 20, No. 2; pp 317-335.

Mubaya, C.P., Njuki, J., Mutsvangwa, E.P., Mugabe, F.T., and Nanja, D. (2012). Climate variability and change or multiple stressors? Farmer perceptions regarding threats to livelihoods in Zimbabwe and Zambia. *Journal of Environmental Management,* Vol. 102; pp 9-17.

Mucina, L. and Rutherford, M.C. (2006). The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African Biodiversity Institute, Pretoria, South Africa.

Mugula, V.J. and Mkuna, E. (2016). Farmer's perception on climate change impacts in different rice production systems in Morogoro Tanzania. *International Journal of Scientific and Research Publications,* vol. 6, issues 2. ISSN 2250-3153

Nhemachena, C. (2007). Local adaptation to climate change in agriculture: experiences from Southern Africa, case study in: Domma A and D. Hirsch 2007. Adapting to climate change: How local experiences can shape the debate. BOTH ENDS, Amsterdam.

Nhemachena, C., Mano, R., Mudombi, S. and Muwanigwa, V. (2014). Perceptions on climate change and its impact on livelihoods in Hwange district, Zimbabwe, Jamba: *Journal of Disaster Risk Studies* 6(1), Art. 123, 6 pages. http://dx.doi.org/10.4102/jamba.v6i1.123

Niggol, S. and Mendelsohn, R. (2008). A Ricardian analysis of the impact of climate change on South American farms. *Chilean Journal of Agricultural Research,* Vol, 68 pp 69-79.

Nyanga, P.H., Johnsen, F.H., Aune, J.B. and Kalinda, T.H. (2011). Smallholder farmers' perceptions of climate change and conservation agriculture: Evidence from Zambia. *Journal of Sustainable Development,* Vol 4, No 4.

Oduniyi, O.S. (2013). Climate change Awareness: A case study of Small scale Maize Farmers in Mpumalanga province, South Africa. MSc dissertation. Department of Agriculture and Environmental Science. University of South Africa.

Olayinka, O.O., Adebowale, K.O. and Olu-Owolabi, I.B. (2013). Physiochemical properties, morphological and X-ray pattern of chemically modified white sorghum starch (Bicolor-Moench). *Journal of Food Science and Technology.* Vol. 50, No. 1, pp 70-77.

Onder, M., Ceyhan, E., Kahraman, A. (2011). Effects of agricultural practices on Environment. *International conference on Biology, Environment and Chemistry. IPCBEE,* Vol. 24. . IACSIT, Singapore. pp 28-32.

Otsuka, K., Haymi, Y. (1988). Theories of share of tenancy: A critical survey. *Economic Development and Cultural Change.* Vol. 37(10), pp 31-68

Polit, D.F. and Beck, C.T. (2004). *Nursing research: Principles and methods (7th Edition).* Lippincott Williams and wilkins, New York.

Rao, K.P.C., Ndegwa, W.G., Kizito, K. and Oyoo, A. (2011). Climate variability in rainfall and associated risk in semi-arid Kenya'. *Experimental Agriculture.* Vol. 47, Issue 2, pp 267-291.

Rutherford, M.C. and Westfall, R.H. (1986). The biomes in Southern Africa-an objective categorization. *Memoirs of the Botanical Survey,* 81:260-268

Slegers, M.F.W. (2008). "If only it would rain": Farmers' perceptions of rainfall and drought in semi-arid central Tanzania'. *Journal of Arid Environments.* Vol. 72, Issue 11, pp 2106-2123.

South Africa Info, Stat SA (2015). Information gateway to South Africa for Mpumalanga Province. Retrieved April 1st, 2015 at

https://www.SouthAfrica.info/about/geography/Mpumalanga.

South Africa. (2009). *Weather SA.* Retrieved April 21st, 2016 at http://www.weathersa.co.za.

South Africa. (2015). *Weather SA.* Retrieved April 25st, 2016 at http://www.weathersa.co.za.

South Africa Explore (2017). South Africa explored. Retrieved July 15th, 2017 at https://www.sa-venues.com>weather.

Statistics South Africa (2011). South Africa's population census Retrieved April 1st, 2015 from https://www.statssa.gov.za/publications/p03014/p030142011.pdf

Tadross, M.A., Hewitson, B.C. and Usman, M.T. (2005). The inter annual variability of the onset of the maize growing season over South Africa and Zimbabwe. *J. Climate,* Vol. 18; pp 3356-3372.

Thornton, P.K., Jones, P, G., Ericksen, P.J. and Challinor, A.J. (2011). Agriculture and food systems in sub – Saharan African in a 4°C+ world. *Philosophical Transactions of the Royal Society.* Vol. 369; pp 117-136.

Traerup, S.L.M. and Mertz, O. (2011). Rainfall variability and household coping strategies in Northern Tanzania: a motivation for district – level strategies. *Regional Environmental Change,* Vol. 11, No 3: pp 471-481

United States Environmental Protection Agency, USEPA. (2014). Climate impacts on agriculture and food supply. Retrieved March 18th, 2016 from: https://www.epa.gov/climatechange/impacts/agriculture.html

United Nations Framework Convention on Climate Change, UNFCCC. (1992). United Nations. FCCC/INFORMAL/84 GE.05-62220(E) 200705. Retrieved July 8th, 2015, from https://www.unfccc.int/resource/docs/convkp/conveng.pdf

United Nations Population Fund, UNPF (2016). World population trends. Retrieved June 1st, 2016 from: https://www.unfpa.org/world-population-trends.html

Valdivia, R.O., Stoorvogel, J.J., and Antle J.M. (2012). Economic and environmental impacts of climate change and socio-economic scenarios: A case study on a semi-subsistence Agricultural production system. *The International Journal of Climate Change, Impacts and Responses.* Vol. 3. No. 2. pp 157 -176.

Watson, B. (2010). Climate change: An environmental, development and security issue. Livestock and global climate change international conference proceedings, Tunisia, 17th – 20th May, 2008. pp 6-7.

World Bank (2009). The bank annual report. Retrieved January 4th, 2016, from https://www.worldbank.org/EXTAR2009/Resources/6223977-1252950831873/AR09_complete.pdf

World Bank (2013). The bank annual world development report. Retrieved January 4th, 2016, fromhttps://www.worldbank.org/EXTAR2009/Resources/9304887-1377201212378/9305896-1377544753431/1_Annual report 2013_EN.pdf

Yaro, J.A. (2006). Is deagrarianisation real? A study of livelihood activities in rural northern Ghana. *The Journal of Modern African Studies*, Vol. 44, Issue 1, pp. 125-156.

Ziervogel, G., New, M., Van Garderen, E.A., Midgley, G., Taylor, A., Hamann, R., Stuart-Hill, S., Myers, J. And Warburton, M. (2014). Climate change impacts and adaptations in South Africa.

APPENDIX

QUESTIONNAIRE

DEPARTMENT OF AGRICULTURE AND ANIMAL HEALTH

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

UNIVERSITY OF SOUTH AFRICA

PERCEIVED EFFECT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION IN THE LOWVELD AREAS OF MPUMALANGA PROVINCE, SOUTH AFRICA

NOTE: This information is confidential and is going to be strictly used for the purpose of this research. No information will be disclosed to a third party without your consent.

Tick the spaces provided for your answers

Name of Interviewer:

Date of interview:

Questionnaire number:

District Municipality: Ehlanzeni

Local Municipality: Please tick the appropriate box

Thaba Chweu	Mbombela	Umjindi	Nkomazi	Bushbuckridge

Ward:

SECTION A:

SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENT (FARMER)

1. Age:

<18 years	19- 35 years	36 – 45 years	46 – 55 years	56 years and above

2. Gender: Male [ ] Female [ ]

3. Marital Status:

Single	Married	Divorced	Widowed	Separated	Other (specify)

4. Educational Status: Please tick

University	College	Advanced level	Completed High school	Some High school	Completed primary
Some primary	Completed vocational training	Some vocational training	Adult education	No formal education	

5. Household size: ----------

6. What is your major occupation?

Farming	Employed	Trading	Self employed	Business	Pensioner	No occupation

7. Is farming your major source of income:

Yes	No

CROPS CULTIVATED

8. Which crops do you plant; indicate by writing according in the space provided below?

Cereals (maize, wheat, barley, sorghum, millet)	(i) ---------- (ii) ---------- (iii) ----------
Legumes (beans, peas, soya, dahl, lentils, peanuts)	(iv) ---------- (v) ---------- (vi) ----------
Vegetables	(vii) ---------- (viii) ---------- (ix) ----------
Fruit	(x) ---------- (xi) ---------- (xii) ----------
Other (Specify)	(xiii) ----------

9. Indicate by making a tick why you are planting this crop(s)

	Response
Personal consumption ---------- 1	
Mostly own, but small surplus is sold out ---------- 2	
Commercial purposes ---------- 3	
Industrial purposes ---------- 4	
Other, please specify ---------- 5	

LAND CHARACTERISTICS

10. Land tenure system

Private (own)	Communal	Permission to own	Renting	Other (Specify)

11. Who owns the farm?

Individual	Family members	Farmers' group	Corporation/ Company farm	Trust	Other (Specify)

12. Who manages the farm?

Individual	Family members	Farmers' group	Corporation/ Company farm	Trust	Other (Specify)

13. What is the size of the farm?

< 1hectare	1–5 hectares	6 – 10 hectares	11 – 15 hectares	16– 20 hectares	>20 hectares

SECTION B:

CLIMATE CHANGE INFORMATION AND AWARENESS; PLEASE TICK IN THE APPROPRIATE BOX BELOW.

1. Do you receive information on climate change?

Yes	No

2. Is there any awareness on climate change in your locality?

Yes	No

3. Are you aware of climate change?

Yes	No

NB: If "No", please go to next section on "perceptions of climate change".

4. If Yes in 3, do you agree with the following statement

	Response	Code
Climate change results in increased frequency of droughts in the areas		1 = Strongly agree 2 = Agree 3 = Undecided 4 = Disagree 5 = Strongly disagree
Climate change results in increased frequency of floods in the areas		
Some of the activities being done by human beings contribute to climate change		
Uncontrolled burning of forests contribute to climate change		
Exhaust fumes (CO_2) from vehicles contribute to climate change		
Emissions (CO_2) from industries contribute to climate change		
Uncontrolled cutting down of trees contribute to climate change		
There are many ways human can implement mitigation strategies on climate change		
Planting of trees will help to mitigate climate change		
Some areas will receive more rainfall while others will receive less rainfall than they used to receive		

5. If yes in 3, did you get to know about climate change from the following

	1 = Yes 2 = No
Learnt from formal schooling	
Learnt from non-formal schooling (adult education)	
Read or read about it in media (newspapers, magazines, newsletters, radio, television, internet etc.)	
Extension system	
From other people	
Own observation	
Other	

6. If responded Yes in 5, please rank the responses starting with the most important in contributing to your knowledge of climate change

	Response	Code
Learnt from formal schooling		1 = Most important 2 = Second most important 3 = Third most important 4 = fourth most important
Learnt from non-formal schooling (adult education)		
Read about it in print media (newspapers, magazines, newsletters etc.)		
Heard it from electronic media (radio, television, internet etc.)		
Extension system		
From other people		
Own observation		
Other		

7. Does the information you get make any difference in your production?

Yes	No

SECTION C:

FARMERS' OBSERVATION ON CLIMATE CHANGE

1. Have you observed any climatic changes?

Yes	No

2. If yes, which of the climatic variables is changing?

Rainfall	Drought	Increased Temperature	Strong wind	No wind	Other (specify)

3. What perceptions did you have on long term rainfall changes?

Increase rainfall	
Decrease rainfall	
Rainfall has not changed	
No changes of rainfall are observed	
Other, (specify)	

4. What perceptions did you have on long term rainfall changes?

Increase temperature	
Decrease temperature	
Temperatures has not changed	
No changes in temperature are observed	

Other, (specify)	

5. What perceptions did you have on long term wind changes?

Increase whirl wind	
Increase in normal wind	
Wind blowing has no changed	
No changes in wind blowing have been observed	
Other, (specify)	

6. Have you experienced the following in your area?

Floods	Drought	Strong wind	Increased temperature	Decreased temperature	Frost	Other (specify)

7. How has climate change affected your crops?

	Response	Code
Increased production		1
No change in production		2
Decreased production		3
No production		4
Other (specify)		7

8. What impacts has climate had on your livelihood?

	Response	Code
Increased socio- economic problems		1
Decreased socio- economic problems		2
Reduced income		3
Increased income		
Increased unemployment		4
Reduced cultivated lands		5
Reduced cultivated practices		6
Increased cultivated land		

9. What impacts has climate had on agricultural production?

	Response	Code
Increased land fertility		1
Reduced land fertility		2
Increased crop yield		3
Reduced crop yield		4
Increased crop diseases		5
Decreased crop diseases		6
Increase livestock production		7
Reduced livestock production		8
Other, specify		9

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

	Response	Code
Increased employment		1
Decreased employment		2

Increased income		3
Reduced income		4
Scarcity of food		5
Reduced food prices		6
Increased food prices		7
Lack of local markets		8
Other (specify)		9

SECTION D:

FARMERS ADAPTATION MEASURES

1. For how long have you been a farmer?

Never	Less than 2 years	Between 2-5 years	Between 6-10 years	Between 11-15 years	Between 16-20 years	21 years and more

2. Did you adapt/cope to climate change?

Yes	No

3. What are the perceived adaptations options?

	Response	Code
Plant different crops (multi-cropping)		1
Plant different varieties of crops		2
Crop diversification		3
Use different planting dates		4
Move to different farm land		5
Crop rotation		6
Change the amount of land		7
Change crops farming to livestock farming		8
Change to mixed farming (planting crops and livestock together)		9
Change from farming to non-farming		10
Increase irrigation system		11
Change the use of chemicals, fertilizers and pesticides		12
Increase water conservation		13
Soil conservation		14
Use insurance		15
Use subsidies		16
Use prayer		17
Other, specify		18
No perceived adaptations		19

4. What measures did you take to adapt to climate change?

5. If you did not adapt, what made you not to adopt adaptation measures?

	Response	Code
Lack of information		1
Lack of money		2
Not aware of climate change		3
Do not know what to do		4
Lack of technical-know-how		5
Distance to weather stations		6
Distance to input markets		7
Differences in agro ecological zones		8
Other, specify		9
Not applicable		10

Thank you for your time.

Compiled by: Ajala ‘Seun Boluwatife, University of South Africa