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FARMERS' AWARENESS OF CLIMATE CHANGE AND VARIABILITY AND IT'S EFFECTS ON AGRICULTURAL PRODUCTIVITY: (THE CASE OF KING SABATA DALINDYEBO MUNICIPALTY IN EASTERN CAPE)

By

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DEDICATION

I dedicate this work to my father, mother, sisters, brothers and my entire family as well as my friends. Further, I dedicate this dissertation to everyone who supported and encouraged me throughout the process of prosecuting this dissertation.

DECLARATION

I, Lelethu Mdoda (Student Number: 200901693), hereby declare that the work contained in this dissertation is my own original work and has not previously been submitted in part or in its entirety, at any educational institution, for a similar or any other degree. Information obtained from other scholars' works referred to here has been duly acknowledged.

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LELETHU MDODA DATE

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ABSTRACT

Climate is an important factor of agricultural productivity and many rural dwellers in developing countries depend on agriculture and are highly affected by climate change and variability. The world is currently experiencing climatic changes and variability conditions which results in high temperatures, low rainfall patterns, shortage of water and drought persistence. Climate change and variability is affecting weather patterns and shifting seasons which results in serious repercussions on smallholder farmers. Smallholder farmers are extremely vulnerable to climate change and variability because their farming and production systems are climate sensitive and are not rebound to climate stresses. These adverse effects in developing countries arise from different climate change and variability-related causes, notable extreme weather events, food security, increased health risks in agriculture from vector home diseases, and temperature-related morbidity in environments.

The study was carried in King Sabata Dalindyebo Municipality in the Eastern Cape Province in South Africa. This study examines farmers' awareness of climate change and variability and its effects on agricultural productivity in King Sabata Dalindyebo municipality using a Descriptive Statistics, Binary and Ricardian Model fitted to data from a cross-sectional survey of 200 farmers in King Sabata Dalindyebo Municipality. Both primary and secondary data was used. This research study estimates the effects of climate change and variability on King Sabata Dalindyebo agricultural productivity using a continental dimension of Ricardian analysis. Results revealed that local farmers were aware of climate change and variability and perceived changes in average temperatures and rainfall. The changes in average temperatures and rainfall had adverse effects on crop and livestock production. However, farmers' awareness of climate change is not to an extent that they presume adaptation to climate change as a necessity and crucial.

The results show that climate change and variability affects farm income and there is a non-linear relationship existing between climatic variables (temperature and precipitation) and farm income which depicts U-shaped. The study results indicated that climate change and variability affect agricultural productivity and have an effect on agricultural productivity in King Sabata Dalindyebo Municipality.

In view of the research findings, several policy proposals are suggested. The study findings suggest that climate change and variability must be taken seriously and monitored. Policy makers and government officials must support farmers with information distribution,

education, market access, well trained extension agents, credit and information about mitigation strategies to climate change and variability which includes institutional and technological methods, particularly smallholder farmers.

Key words: Ricardian model, agricultural productivity, climate change, variability, farmers' awareness, adaptation strategies, crops and livestock, King Sabata Dalindyebo Municipality, Eastern Cape

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AGRA -	Alliance for a Great Revolution Africa (AGRA)
DAEA-	Department of Agriculture and Environmental Affairs
DAFF -	Department of Agriculture, Forestry and Fisheries
DST -	Department of Science and Technology
DWA -	Department of Water Affairs
FAO -	Food and Agriculture Organization of the United Nations
ECDWA -	Eastern Cape Department of Water Affairs
GDP -	Gross Domestic Product
GMOs -	Genetic Modified Organisms
HDI -	Human Development Index
IFRI -	International Food Policy Research Institution
IFPRI -	International Food Policy Research Institute
IPPC -	Inter-governmental Panel on Climate Change
KSD -	King Sabata Dalindyebo
NDA -	National Department of Agriculture
NEB -	Negative Energy Balance
SAFWI -	South African Fruit and Wine Initiative
SAWS -	South African Weather Services
SEPA -	Scottish Environmental Protection Agency
SSA -	Sub-Sahara Africa
SPSS -	Statistical Package for Social Scientists
TV -	Television
UN -	United Nations
USAID -	United States Agency for International Development
USCCSP -	United States Climate Change Science Program
USGCRP -	United States Global Change Research Program’s
WMO -	World Meteorological Organization

CHAPTER ONE

INTRODUCTION

1.0 Introduction to the chapter

This study sought to investigate smallholder farmers' awareness of climate change and variability and its effect on agricultural productivity. This chapter introduces the problem statement, objectives and research questions, hypothesis of the study, as well as the justification and the limitations of the study.

1.1 Background of the study

Agriculture is the backbone of African economies because 70 % of the people in sub-Saharan Africa live in rural areas and rely on agriculture for their livelihood security (FANRPAN, 2013). Agriculture is one of the leading sectors in employing labour force in Africa. Agriculture employs about 65% of Africa's labour force and it accounts third in Gross Domestic Products (Alliance for a Green Revolution in Africa (AGRA), 2014). Agriculture is an important sector in the South African economy despite its small share of 4.5% of Alliance for a Green Revolution in Africa (AGRA), 2014). The country's Gross Domestic Product (GDP) (Department of Agriculture, Forest and fisheries (DAFF), 2012). Agriculture is vital because it provides food and fibre to meet basic needs of people (DAFF, 2012). However, due to an ever increasing population growth, agricultural productivity must increase to meet the increasing demand (Alliance for a Green Revolution in Africa (AGRA), 2014). Agricultural productivity is currently being negatively affected by many factors which include climate change, socio-economic factors, technical and institutional constraints. The effect of climate change could lead to a decrease of almost 1.5 % in the country's GDP mainly as a result of reduced agricultural productivity (Statistics South Africa (Stats SA), 2007). According to the Inter-governmental Panel on Climate Change (IPPC) (1990), climate change and variability will lead to a decrease in agricultural productivity because agricultural activities are sensitive and vulnerable to climate change.

Mandleni (2011) stated that, climate change and variability are global events occurring worldwide and are affecting all countries in the world including South Africa. The change in climate and variability are the biggest challenges the world is facing and it has become one of

the main fears to many farmers and communities because of the unpleasant effects it has on agricultural productivity. Developing countries will bear the burden of the adverse consequences of climate change and variability mostly because of the elevated poverty levels and a diminished capacity to adapt to climate change and variability. Herrero *et al.* (2010) mentioned that, as climate change and variability is a worldwide phenomenon, the African continent is getting warmer and warmer more than it was in the past 100 years due to changing climate and variability. As such, the GHG (Greenhouse gas) model which Herrero *et al.* (2010) used shows that the African continent will continue to warm and in most scenarios will accelerate. It has been highlighted that the warming rate of the African continent was 0.05^0C per decade during the 20^{th} century and such warming is continuously rising as global climate change and variability also continue rising. Climate change and variability will have adverse effects on agriculture because climate change and variability retards productivity. As postulated by environmental researchers, Southern Africa will be heavily hit by climate change and variability. It is projected that in the coming 70 years, productivity in agriculture is going to be halved. As a result of climate change and variability the Southern African regions will experience more and longer droughts, increased crop failures and have less fields and pastures due to water shortages (FAO, 2010).

Climate change is defined as any long-term and significant change in the expected patterns of a specific region's average weather for an appropriately significant period of time (Cruz *et al*, 2007, Mandleni, 2011). These changes in average weather patterns are a result of several factors which are natural in nature and also as a result of human activities (Nzuma *et al*, 2010). Climate change is expected to have a negative effect on agricultural productivity, hydrologic balances, input supplies, exploitation of natural as well as environmental resources and other components of agricultural systems. This change in climate has a negative impact on farmers, especially smallholder farmers because these farmers have limited resources (Du Toit, 2003, IPCC, 2007 and Mandleni, 2010). This issue has motivated a substantial body of research on climate change and agriculture over the past decade because agricultural productivity is climate dependent (FAO, 2010 and IPCC, 2007).

Climate change and variability, which may make temperatures rise and reduce the rains and change their timing, may therefore put more pressure on the country's scarce water resources, with implications for agriculture, employment and food security and furthermore, these changes in climatic conditions will have significant effects on national economies, rural

livelihoods and development in general (IPCC, 2007, Madzwamuse, 2010). Moreover, these changes in climate and variability will have a negative effect on the hydrological system and soil type of the country as well, for example will affect the river flow, some of the water sources and damaging the soil, making more acidic and also compacted (IPCC, 2007 and FAO, 2010). According to Madzwamuse (2010), climate change is an impending threat facing the world in the 21st century and beyond.

Nowadays, it is widely accepted that the earth's climate has become increasingly warmer, most likely due to increasing greenhouse gas emissions. Climate change, a phenomenon synonymous with global warming and the greenhouse effect is projected to continue (IPCC, 2001). Major effects of climate change have been noted to include a rise of the mean temperature between 1.5 to 5.8 ºC by the end of the next century, the frequency of droughts, an increase of sea levels and the frequency of floods and heavy rains and an alteration of wind directions (IPCC, 2001). According to Kean *et al*. (2009), Krunger (2004), the changes in climate and variability will have significant effect on farmer's lives and will hinder their productivity in agriculture because farmers lack information regarding these changes. This will result in a reduction in the amount of land suitable for farming agricultural productivity, reduces length of growing season and yields as well mostly in the semi-arid and arid regions of the country. This will further more reduces the contribution of agriculture have on the country's GDP (FANRPAN, 2013). The rural household will be the most affected because rural populations are heavily dependent on this sector as a source of income and employment as well as livelihood security (Ringler, 2008, FANRPAN, 2013).

Vulnerability is the degree to which a system is susceptible to, or unable to cope, with adverse effects of climate change, including climate variability and extremes (IPPC, 2001). Vulnerability is seen to comprise three components namely: exposure, sensitivity and adaptive capacity (Okumu, 2013, IPCC, 2007). Exposure refers to the presence of a climate hazard while sensitivity is determined by the responsiveness of a system to the climate hazard. Adaptive capacity is the ability of a system to change in a way that makes it better equipped to manage its exposure and sensitivity to climate change (Okumu, 2013). Agricultural productivity is very sensitive to climate change and variability, so the minute these changes happen it exposes farmers' to such hazardous climate which will have a negative effect on agricultural productivity because of its sensitivity to hazardous climatic events. Due to sensitivity of agricultural productivity to vulnerability, it is vital for farmers to

adapt to climate change and variability because it minimizes the effect that is caused by these changes in climatic conditions (Mandleni, 2011). The use of adaptation to climate change and variability will significantly reduce vulnerability to agricultural production (Smit and Skinner, 2002).

Changes in climate are unavoidable even under stringent mitigation measures over the next few decades (IPCC, 2007). These changes are inevitable due to high concentrations of greenhouse gases and high residual levels of greenhouse gases in the atmosphere (Klein *et al*, 2007). Due to pressure that climate change and variability have on agricultural productivity and livelihoods of people especially who depend on agricultural productivity for living, without any doubt there is need for adaptation strategies which will help in mitigating climate change and variability (Alliance for a Green Revolution in Africa (AGRA), 2014). Adaptation efforts to lessen the sources of or to enhance the sinks of greenhouse gases will take time (IPCC, 2007). Therefore, effective adaptation requires collaboration and commitment from many countries (Klein *et al.*, 2007). Adaptation strategies to climate change and variability will assist in sustaining agricultural productivity because it will reduce these changes of climate and variability to an acceptable level (Slingo *et al*, 2005). Adaptation is therefore critical and of concern in developing countries, particularly in Africa where vulnerability is high because ability to adapt is low (Slingo *et al.*, 2005). There is low adaptation to climate change and variability because farmers have limited resources that can help them adapt to some changes in climate (Alliance for a Green Revolution in Africa (AGRA), 2014).

1.2 Problem Statement

Climate change and variability is a global phenomenon which is affecting seasonal shifts which leads to changes in planting dates and weather patterns with severe adverse effects on farmers and rural communities (Okumu, 2013). Due to the fact that climate is the determinant and linked with agriculture, studies and policy makers have expressed their concerns about possible and adverse effects posed by climate change and variability on agricultural productivity.

Climate change and variability is global because it affects all countries in the world (Mandleni, 2011). According to Mandleni and Anim (2011), it is one of the biggest environmental challenges. It has become a major concern to society because of its adverse

effects. There are already increasing concerns globally regarding changes in climate that are threatening to transform the livelihoods of the vulnerable population segments. The earth's climate has warmed on average by about 0.7◦C over the past 100 years with decades of the 1990s and 2000s being the warmest in the instrumental record (Watson, 2010).

South Africa has been highlighted to be vulnerable to climate change due to its low adaptive capacity and its sensitivity to climatic changes (IPCC, 2007). The manifestation and effects of climate change have resulted in developmental stresses, which particularly worsen the poverty rate which is 48.4%, land degradation which is 25%, unemployment rate which is 26.6% and food insecurity (45.4%) in combination with environmental changes (drought and land degradation) (FAO, 2006, Thomas, *et al*, 2008, WHO, 2011). The forecasts about climate change and variability made by the researcher in South Africa reveal that some of the species of crops and livestock had disappeared or died as a result of climate change and variability due to high temperatures which reduce water availability in underground, bore holes as well as dams which are essential for agricultural productivity (Lobell and Burke, 2008).

Climate change and variability manifestation had resulted in the decline in agricultural productivity, unpredictable and depress in crops yields, livestock loses, which have led to food shortages and over-reliance on an emergency food base intervention taken by the government to meet the growing population and food deficit by local dwellers (Okumu, 2013). In particular, rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear more burdens of adverse impacts of climate change and variability. The extent to which these impacts are felt depends in part on the extent of adaptation in response to climate change. There are many rural households, especially in the Eastern Cape as the province is entirely made up of rural areas and is the second biggest province in South Africa, the effect of climate change and variability will adversely affect these households in the province.

Climate change and variability have further resulted in adverse effects on land use and the land use system as it has resulted in the reduction in the lengths of growing seasons a development which has made agricultural productivity more variable than ever (Mandleni, 2011). The decline in agricultural productivity has resulted in an increase in the unemployment rate of South Africa as the agricultural sector employs more than 50% of the country's labour force. This has in turn caused a rise in food prices. This rise of food prices

has resulted in an increase in poverty rates as most people depend on agriculture for living. It will have further adverse effect of reducing food productivity which is more demanded as population increases as available food production is declining due to climate change and variability. There is high and increase in irrigation cost and soil improvement as result of variability and changes in climate which resulted to a rise in agricultural investment.

The changes in climate and variability has resulted in outbreaks of waterborne diseases caused by a variety of micro-organism, toxic contaminants and bio-toxins which results in overwhelming illnesses such as cholera, dysentery, schistosomiasis, other gastrointestinal problems and diarrheal diseases which affect livestock and crops.

Climate change and variability has been acknowledged to have adverse effects on agriculture, evidence from studies conducted in the African countries, Europe, USA and in other parts of the world. Turpie *et al.* (2002) climate change and variability forecast in South Africa show that certain species of animals will become extinct as a result of climate change. According to Provide (2005), agricultural practice is largely practiced by rural residents where they soley depends on agriculture for living and it is about 94.7 percent of rural households that practise agriculture in the Eastern Cape province. Agriculture is the backbone of South African economy and farming is one of the practice largely practice in South Africa as it is predominant practice for livelihoods in many provinces of the country. Poverty and food insecurity are high in rural areas where most people depends solely on agriculture for living livelihoods.

Eastern Cape Province however is the second largest province and second poorest province in terms of per capita income in South Africa when compared to other provinces (Mandleni, 2011). The study of farmers' awareness of climate change and variability as well as its effects on agricultural productivity would be very important because the extent of farmers' awareness of climate change ad variability is very essential together with exploring adaptation measures used to cope with climate change and variability. Adaptation measures are very important because they are meant to save agricultural practices (crop, livestock and mixed farming) in the province. The South African National Networking Meeting on Climate Change Adaptation (SANMCCA) identified gaps and shortcomings in adaptation in all provinces of South Africa. The prominent gaps and shortcomings identified were rural bias in projects whereby focus was at national level, lack of voice from civil society, government failure to integrate activities and minimum contribution from research.

There is little literature available that covers the effect of climate change and variability on agricultural productivity. The available literature is covering few crops and livestock (Kiker *et al*., 2002, Benhin, 2006). Despite handful empirical studies conducted all over the world in-depth analysis and entrenched scientific evidences on the nature and extent of climate change and variability, the magnitude of climate change and variability effects on agricultural productivity and socio-economic consequences on the livelihoods and food security of the rural poor and farmers in the area is practically lacking. However, despite the importance of agricultural productivity in South African economy and livelihoods, there is very or not enough existing studies on climate change and variability as well as its effect on agricultural productivity.

This study is intending to address the gap in literature by examining farmers' awareness of climate change and variability and to investigate effects of climate change and variability in agricultural productivity in King Sabata Dalindyebo Municipality using a cross-sectional survey data. This study also intends to examine the coping strategies used by smallholder farmers' in efforts to mitigate the effects of climate change and variability in KSD Municipality in the Eastern Cape Province.

1.3 Research Objectives

Main objective

The main objective of the study is to explore and analyse the impact of climate change on agricultural production in King Sabata Dalindyebo Local Municipality in the Eastern Cape.

The specific objectives of the study are as follows:

i) To examine farmers' awareness on climate change and variability in the King Sabata Dalindyebo Municipality.

ii) To investigate the marginal effects of climate change and variability on agricultural farm revenue.

iii) To examine the farmers coping strategies to climate change and variability.

1.4 Research questions

The study is guided by the following operational questions:

1. What is farmers' level of awareness on climate change and variability?

2. What is the marginal effect of climate change and variability on agricultural farm revenue?

3. What are the existing strategies that smallholder farmers in the municipality are using to cope with climate change and variability effects?

1.5 Hypothesis

In order to achieve the general objective of the study, the following specific hypotheses were tested:

1. Farmers in King Sabata Dalindyebo Municipality are unaware of the changing trends in climate and variability;

2. Farmers' income is negatively affected by climate change and variability; and

3. Farmers in King Sabata Dalindyebo Local Municipality do not have coping strategies against climate change and variability.

1.6 Delineation of the study

The study will be limited to King Sabata Dalindyebo local Municipality which is under the Oliver Reginal Tambo District Municipality of the Eastern Cape Province due to the lack of financial resources and time constraints. The households in this Municipality are scattered from one another making data collection costly. The study will focus on this local municipality only and it will be focusing on smallholder farmers' who are practising agricultural production. In addition there is poor accesse to roads in the villages resulting in significant challenges in accessing of some of the households.

1.7 Justification of the study

Currently, there is insufficient information available on the awareness of farmers concerning the dangers that climate change and variability pose to agricultural productivity in South Africa, especially in rural areas. This study may assist the government and other stakeholders in decision making and to inform farmers and communities in order to minimise the negative effects of climate change. The information generated in this study will assist policy makers in revising existing policies and to formulate effective strategies that will minimize the effect of climate change and variability to the environment and humans. The study will make farmers understand and be aware of the concept of climate change and variability and also provide appropriate adaptation recommendations to policy makers as well as assisting farmers on adaptation strategies and mechanisms in dealing with climate change and variability thereby enhancing agricultural productivity.

This study will encourage other researchers to undertake similar studies in other areas of the country as well as the whole of the Eastern Cape Province and also inform farmers about planning guidelines for climatic risks in terms of food and water security.

1.8 Ethical considerations

The study was approved by the Faculty Research Committee of Science and Agriculture. The proposal and questionnaires were submitted to University of Fort Hare's Ethical Committee to seek ethical clearance. The respondents were informed about the research as well as its purpose and respondents were also assured of the confidentiality clause in the research that it will be observed professionally. The researcher further explained fully to respondents that participation in this research is voluntary and that any respondents must feel free to participate in the research but could pull out of the research at anytime they wished to. The respondents were given assurance that there will be no penalties, prejudice and come backs in any way in their participation in this research study.

The researcher explained to the Traditional Authorities the purpose and the value of the research, and why these areas were selected as the study area. In data collection, the local language, IsiXhosa was used in interpretation and translating questions to respondents.

1.9 Expected uses and users of research results

It is anticipated that the project results will:

• Be of direct benefit to the government and councils in the study area and beyond;

• Encourage other researchers to undertake similar studies in other areas;

• Inform planning guidelines for climate vulnerability and impacts in terms of adaptation;

• Inform planning guidelines for climatic risks in terms of food and water security;

• Provide appropriate adaptation recommendations to policy makers; and

• Benefit smallholder farmers in and King Sabata Dalindyebo Municipality as well as the Eastern Cape Province who will profit from more effective and timely adaptation measures.

1.10 Dissertation outline

This dissertation comprises of six chapters. Chapter one introduces the study. Chapter two discusses the literature review. The literature relevant to the farmers' perceptions of climate change and variability as well as its effect on agricultural productivity is discussed. The third chapter deals with the selection and description of the study area, covers the research methodology which describes how the data was collected and analyzed. Chapter four presents the descriptive results and chapter five presents the empirical results of the study. Lastly, chapter six summarises the findings made from the study, and it encompasses the conclusion and recommendations which emerged from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction of the chapter

The purpose of the study is to investigate effects of climate change and variability on agricultural productivity. The literature review examines the concept of climate change and variability and its implication on agricultural productivity and livelihoods. The literature review chapter is divided into four main sections namely: (i) a review farmers perception on climate change and variability through reviewing past studies on climate change and variability among agriculture and smallholder farmers; (ii) the review of climate change and variability manifestation; (iii) the review of climate change and variability impacts on agricultural productivity; and (iv) the review of adaptation measures to mitigate climate change and variability on agricultural productivity.

2.2 Climate change and variability overview and farmers' awareness

2.2.1 Climate change and variability

Climate change and variability is the change of weather conditions over time and it is either caused by the human activities or the emission of the greenhouse gases from the industries (IPCC, 2007). Mandleni (2011) noted that, climate change and variability is a global event, and South Africa is not the only country experiencing this disaster. It is further speculated that climate change and variability is widely characterized by weather events which are escalating throughout the world and are more than likely to happen in the future and it is the biggest challenge the world is currently experiencing. South Africa is particularly vulnerable to climate variability and climate change as farming depends largely on the quality of the rain season. Climate change and variability can make temperatures climb and rainfall diminish thus putting more pressure on the country's scarce water resources, with implications on agriculture, employment and food security as well as neglecting sustainable development (IPCC, 2007).

The average temperature on the planet has been increasing in recent decades (global warming), resulting in more extreme and unpredictable weather across the world. South Africa has been getting hotter over the past centuries at an average temperature of 0.13^0 C.

These changes contribute to global warming, hindering productivity in agriculture, and thus affecting livelihoods dependent on it. In this sense, food security is thwarted and employment in the sector depreciates. Increases in temperatures have many other effects; for example, they will lead to a decline in agricultural productivity around the world because most people depend on agricultural activities for survival and source of income. This will reduce food available for the growing population in the world and increases the unemployment rate. This increase in temperatures throughout the world will lead to the melting of Ice land's galciares which will result in flooding and water run-offs contributing to soil erosion (IPCC, 2007, Mandleni, 2011 and FAO, 2010).

The change in temperatures will be hugely characterised by a persistence of drought and new wet periods due to floods events. The occurrence of extreme precipitation such as acid rain has increased and become more frequent in recent years. There have been extreme weather events across the globe such as persistence of rainfall, droughts, and storms with a small number of areas not being affected by changes in weather conditions. According to Mandleni (2011), the affected areas due to climate change and variability had experienced overwhelming economies of various countries as well as agricultural productivity. It is argued that the most affected areas are those areas with poor or no infrastructure at all which result in high financial costs as result of such disasters' occurrence. Disasters and lightning events which have resulted in many livestock deaths have imposed elevated costs in South Africa, since most people are living in marginal lands that tend to be fragile and subject to natural disasters. However, because most agricultural productivity in South Africa takes place in moderate and limited areas, which are frequently susceptible to drought and heavy rains, the probability of a decline in productivity is highly significant as result of disasters (Kruger and Shongwe, 2004).

Apart from disasters, drought persistence is one of the damaging factors that a country can face which negatively affects agricultural productivity (Krunger and Shongwe, 2004). Mandleni (2011) argued that always, poor farmers are the most vulnerable to drought persistence as they lack and have low means to adapt to adverse effects of drought. According to Ciais *et al.* (2005) mentioned that the total eco-system productivity as well as total carbon sequestration in Europe had declined as result of recent drought conditions. Drought has affected Europe, America and Africa significantly. For example there was a drought that took place in 1992 which withered Southern Africa and resulted in the death of more than 1 million cattle in Zimbabwe (Musemwa *et al.*, 2012). Furthermore, this drought

resulted in the changing of the veldt settings from sandy soils to clay soils. This resulted in most of the agricultural productivity in such places being affected. It is projected that global climatic conditions are continuing to change at rates which are extraordinary than ever recorded in history. IPCC (2007) stated that there will be a global increase in temperatures as result of greenhouse gas emissions in the atmosphere and this rise in temperatures is expected to be between 1.5 to 6.0 ^{0}C in the year 2100. This rise in temperatures is as a result of the continuation in temperature rise from the 20th century by 0.6 ^{0}C (IPCC, 2001). The rise in temperature is expected to raise evaporation throughout the globe which will result in changes in rainfall patterns.

Climate change is an impending threat facing the world in the 21st century and beyond (Madzwamuse, 2010). The results of increased temperatures, changes in rainfall patterns, extreme weather events, sea level rise and changes in biodiversity will have significant impacts on national economies, rural livelihoods and development in general. Du Toit (2003) and Okumu (2013) indicated that the impact of climate change and variability is felt by the farmers predominantly through changes in timing, frequency and intensity of rainfall events and ultimately productivity. These changes will further reduce the contribution of agricultural productivity to the country's GDP.

Lars *et al*. (2009) made use of an ecological-economic model to investigate the local economic impacts of climate change in the Sahel. The results of the model showed that changes in average annual rainfall or rainfall variability were expected to have a strong impact on the livelihood of the pastoralists in the Sahel. Both the overall profits from livestock keeping, and income per hectare that was obtained from the sector were reduced as a result of lower rainfall. For example, the model indicated that about 15% of the decrease in rainfall combined with a 20% increase in rainfall variability respectively, which resulted in a 15% reduction in the open access stocking density, and a 30% reduction in the optimum stocking density (Lars et al., 2009). The model also indicated that, through a reduction in the overall stocking density, part of the negative impacts of rainfall reductions could be mitigated.

Evidence from previous studies by Liverman and O'brien (1991) in their study conducted in Mexico in climate change effect. Mexico is a country which is mainly prone to suffer and experience at least two different types of climate change events such as hurricanes and droughts. The main reason behind this phenomenon is that Mexico is a developing country

and developing countries have the majority of their economic activities based mainly on agriculture. The World Bank, through its Hazard Management Unit, studied floods, droughts, and cyclones, and discovered that Mexico was ranked 32 out of 60 countries that were affected by two or more potential hazards. Mexico is predicted and likely to face repeated disaster-related losses and costs, leading to recurrent granting of financial relief to regions hit by such events (Liverman and O'brien, 1991).

In a study conducted by Kurukulasuriya *et al*. (2007), in which the Ricardian technique was used to estimate possible impacts of climate change in Sri Lanka on agricultural productivity, the study results showed that climate change had a significant impact on smallholder profitability. The effects of climate change varied across geographic areas, from losses of about 67% to gains of more than double revenues. The most significant negative effects of climate change that were predicted were in the dry areas of the North Central region and dry zones of the South Eastern regions of Sri Lanka. The study further revealed that intermediate and wet zones were more than likely to benefit livestock farmers than crop farmers mostly due to a predicted rise in rainfall.

Keane *et al* (2009) mentioned that African countries are likely to be vulnerable to climate change and variability, and thus the African continent will experience reduction in agricultural yields due to its low ability to adapt to these changes in climate and variability. For example, Guinea's agricultural productivity which constitutes about 62% in the Guinea's GDP will decline to 32.7% in the next decades due to the result of climatic changes and variability effects on agricultural productivity, with the effects worsening by 2080. These changes in climatic conditions will have unpleasant effects in the continent because it will have a massive effect on development and food security. In addition, these changes will also have a massive effect on the African economy and trade flows. This effect will hamper growth and exporting opportunities because agricultural productivity plays a major role in the growth of developing countries. This will lead to disputes among different regions in terms of agricultural output (Keane *et al*, 2009).

A study conducted by Lars *et al.* (2009) in the Sahel using the ecological-economic model to investigate local and economic effects of climate change in the Sahel reveals that average annual precipitation is expected to have adverse effects on the livelihoods of pastoralists in the Sahel region. The study further reveals that farm revenues on both livestock and per hectare income which is derived from the sector will decline as a result of low rainfall. The

model used by Lars *et al.* (2009) shows that a 15% decrease in rainfall patterns and an increase in 20% of variability in rainfall patterns will result in a 15% decrease in the open access of stock density as well as a further 30% decrease in optimum stocking density. Lars *et al.* (2009) further speculated that such decreases in stocking densities are a result of adverse effects of climate change and variability, and such adverse effects can be mitigated through coping strategies and adaptation measures.

According to the study carried by Kurukulasuriya and Mendelson (2006), in which they analysed choices in crop and livestock as climate change adaptation in South Africa, Zambia, Zimbabwe, Egypt, and Cameroon, farmers are aware of climate change and variability because it illustrates that the crop choice is very sensitive to climate change and farmers do adapt to these climate change and variability by interchanging crops. The study also revealed that choices made in livestock show that farmers were aware of these changes in climate and variability because of their knowledge of which livestock they might use in higher temperatures such as goats and sheep instead of cattle and chickens because the latter cannot do well in such dry and harsh conditions.

A study conducted in Cameroon by Molua (2008) on the impact of climate change on Cameroon's Agriculture, shows that climate change is occurring and it does have adverse effects on agriculture. The study revealed that there is about 3.5% increase in average temperatures and about 4.5% increase in precipitation in areas where there is an absence of irrigation systems and such a result will be a disadvantage to Cameroon's agriculture as it results in a decline of 46.8% in output values. The loss that is occurring as a result of climate change was heavily anticipated together with the adverse effects it brought on the country's economy as agriculture consists of 30% of its national GDP. Thus, it can be concluded that climate change is brings negative effects on agriculture as agricultural productivity is declining. Molua (2009) did a similar study on climate change effects on smallholder agriculture in Cameroon, where he utilized the Ricardian Model. The model revealed that there was an increase in average temperatures by 2.5^0C which would result in the reduction of farm net revenues which were expected to be around US$079 billion. The study further revealed that the climate change phenomenon was not good at all for the economy of Cameroon as it has adverse affects on the national GDP and the country's economy at large.

From the studies of Gandure *et al* (2012) conducted in the South African rural communities, it established that farmers have realised that there is a change in climate and variability. The

study also revealed that farmers are aware of climate change and variability and have also recognised the strong effects of heating temperatures and inconsistent rains in the country. High temperatures are leading to a high evaporation rates which results in water scarcity in the reserves for primary agricultural processes. The study further revealed that warmer temperatures are fully associated with high evaporation and evapo-transpiration as well as an increase in water requirement by crops. Gandure *et al* (2012), IPPC (2007), mentioned that under such conditions, the use of yearly rainfall as a real measure of current rainfall which is adequate for agricultural productivity will be confusing. This is attributed to the fact that much rainfall would have already been lost through evaporation and evapo-transpiration respectively. The meteorological data shows that there is a major increase in average temperatures being experienced throughout South Africa in winter, particularly the June temperatures in regions of $1\text{-}2^0$ C and there is less effect on the variability of rainfall in the past 50 years (Grandure *et al*., 2012).

According to a research conducted by Gbetibouo (2009) in the Limpopo River Basin in South Africa for the 2004-2005 seasons, the farmers are aware of climate change and variability because almost 95% of farmers interviewed had experienced long term changes in average temperatures whilst the remaining farmers did not notice any changes in climate and variability. The study made use of a household survey to examine farmers' perceptions on recorded data of climate change. The study further revealed that about 91% of the farmers were aware of the increase and the rest the decrease in temperatures. It has also been noticed that such changes are happening in the summer season.

In terms of rainfall, about 97% of the farmers were aware of the changes in rainfall patterns over the last 20 years and about 81% of these farmers had experienced a decline in the amount of rainfall they are receiving in each season. Another category of farmers had also experienced changes of climate and variability by noticing the timing of rainfall which had changed dramatically from the timing they usually received rainfall. Definitely, rainfall is expected in summer, but due to effects of climate change, it has shifted, either it comes late or in short supply (Gbetibouo, 2009).

According to Mandleni and Anim (2011) in their study carried out in the Eastern Cape Province of South Africa, 86% of the farmers were fully aware of the climate change and variability in the province as a whole. It also revealed that farmers were fully aware of the increase in average temperatures and changes in rainfall patterns due to the fact they knew

that the province is constantly experiencing drought conditions. Approximately, 83% of the farmers were aware of the effects of the harsh weather conditions and were playing a role in the reduction of livestock numbers.

South Africa has been highlighted to be vulnerable in climate due to its low adaptive capacity and its sensitivity to climatic changes (IPCC, 2007) and climate change is seen to be a threat to agricultural productivity in the country. Changes in climate and variability had been outlined to have numerous effects on environmental, economic and social spheres as most rural dwellers and farmers in South Africa hugely depend on agriculture for their wellbeing and income (Mandleni, 2011).

2.2.2 Farmers' awareness on climate change and variability

Climate change and variability has long been perceived as a serious challenge throughout the globe from Europe, Asia and Africa, especially South Africa and action had long been taken to mitigate and cope with climate change and variability effects (IPCC, 2007). There are lots of studies done on awareness of climate change and variability in developing and developed countries. Developing countries such as Africa did not adapt to climate change and variability because they have low capacity to adapt and have no resources to adapt at all.

In a study conducted in the Indo-Gangetic Region in Asia where the researcher was carrying a survey to investigate perceptions of the local people on climate change, Tripathi (2010) made use of temperatures, rainfall, agriculture, weeds and other livelihoods as its variables. The study revealed that the people in the Indo-Gangetic Region indeed perceived a significant change in temperature distribution and a definite reduction in the number of winter months, which then lasted for only two months. The study revealed that almost 100% of the respondents' in Indo-Gangnetic Region do perceive changes in climate change and they widely perceived changes in winter seasons. These perceptions were not in line with traditional weather descriptions because temperatures were way above the normal temperatures as result of change and variability in climatic conditions. Rainfall patterns were perceived to be variable and declining from 1999 until 2008. The respondents had observed that there were changes in rainfall patterns as it started to rain later than usual and this was damaging and harmful for the maturing of crops. The respondents further observed a decrease in the number of cloudy days during the monsoon.

Sharma (2010) in a study of farmers' perceptions on climate change in Himachal Pradesh District in Himalaya in 2010, raised questions on their perceptions on the effect of climate change as well as overall perceptions on the effects of climate change and effects of climate change on agricultural related aspects. The findings revealed that two-thirds of the respondents were aware of climate change. A significant majority had knowledge and information about various types of changes in the climate such as increasing pollution, melting glaciers, cyclone incidents, increased crop failure and a rise in sea-level. A majority of respondents had perceived a decline in food grain production, decrease in the quality of fruit, frequency of rainfall and soil erosion, which resulted in adverse effects in the production of fruits. The overall perception of respondents about impacts of climate change, as revealed by the data used in the study, was that 36% of farmers perceived effects of a change in climate. About 40% was neutral as they did not realise that climate change had effects on them.

Sharma (2010) also revealed that about 40% of farmers in the Himalaya had changed their cropping patterns and the outstanding reasons for the change in their agricultural practising were inadequate chilling hours required, especially in case of fruits. Concerning agriculture, the respondents perceived that the use of fertilizer and pesticides in farming had increased due to climate change that is taking place. This was definitely increasing household expenditures on farming activities as well as outside farming activities.

The indicators of climate change, according to their observations made by respondents, climate change indicators that they had used and observed were increased temperatures and erratic rainfall patterns. The observed results were a reduction in crop and fodder yields, and increased prevalence of diseases and pests. Some villagers and farmers who were ignorant about climate change thought the incidences were an act of God who had become angry with the sinful acts of the villagers. Other villagers in the areas of study were not ignorant about climate change. The only problem was the means to mitigate the effects of climate change that were not available.

A study conducted by Mubaya *et al.* (2010) in Zambia and Zimbabwe, revealed that about 80% of famers were aware of a climate change as they had noticed persistence in droughts and excessive rainfall in the past five years, which had both positive and negative effects on farming and productivity. The study revealed that local communities had a very clear

memory of the years that were dominated by extreme climatic conditions and other major events that affected productivity negatively. Households further perceived an increase in temperatures throughout the year with cold periods being shorter than warm and hot periods respectively. Winds were also perceived to be stronger especially in dry seasons. Households perceived reduced rainfall as a major challenge to their farming whereas others perceived excessive rainfall. Wind was also mentioned as another problem in the area of study (Mertz *et al*., 2009).

From literature reviewed in this chapter, farmers throughout the world and Africa, especially South Africa have perceived changes and variability in climatic conditions and are fully aware of its effects in productivity. The literature reveals that climate change and variability is existent and many farmers have become aware of this development in many countries across the globe. According to Mandleni (2011), climate change and variability has been perceived by farmers in terms of drought persistence, severe heat and temperature, heavy rainfall and floods which come at unexpected times of the year, and resulting in disasters. On the other hand, farmers have perceived changes in climate conditions in terms of declining rainfall patterns and change in rainfall which normally starts later than in normal times. Awareness has also seen in terms of extreme heat which has been seen as leading to pests and termite outbreaks which results in diseases in livestock. Perceptions were further experienced in terms of an increase in sea-level, incidences of cyclones and increased pollution.

The effects of climate change and variability have been negative in terms of reducing agricultural productivity as well as bringing economic and social instabilities. The changes and variability in climatic conditions have affected livelihoods of farmers. This phenomenon has further had adverse effects in consumers' welfare and households as well as their economies. The extreme heat and excessive rainfall levels have affected agricultural productivity adversely, increased disease incidence in agricultural productivity and reduces household incomes from agricultural productivity being practiced.

The most undesirable aspect about climate change and variability is that it has been noticed to affect the poor. The poor have become vulnerable to climate change and variability due to the lack of resources to adapt to climate change and variability. These negative impacts had negative effects on the economies of the countries such as GDPs.

However, as much as climate change and variability brings negative impacts on agricultural production, there are various manifestations of climate change and variability which leads to adverse effects on agricultural production such as change in average temperatures, change in average rainfall and extreme weather events. These manifestations have different impacts on agricultural production such impact maybe positive or negative.

2.3 Manifestations of climate changes that affect agricultural productivity

2.3.1 Change in average temperatures

South Africa is a warm country which experiences annual temperature of above 17^0 C and the coastal areas of the country are the ones which are the warmest areas while southern and eastern regions of the country are experiencing lower temperatures (Landman *et al*., 2010b). Krunger and Shongwe (2004) mentioned and highlighted that South Africa has been getting hotter and hotter over the past decades where average temperature is rising by 0.13^0 C per decade.

The situation could be worse in the future because average temperatures are predicted to increase over the whole of South Africa due to climate changes. Temperatures in January are assumed to rise between 2.3 to 5.0^0c in the central areas and 0.5 to 1.5^0c in the coastal areas of the country. According to IPCC in 2001, South Africa is predicted to be drier in terms of climate conditions. According to DST (2010), the principal increase in the average temperature is predicted to take place in winter and autumn respectively, while there will be a minimal rise in temperatures in summer and spring. The South African temperature is said to be increasing faster than the rise in global temperatures with these changes in average temperatures resulting in changes in the evaporation process.

However, similar changes in average temperatures are being experienced in other places. For example, in Zambia, farmers have experienced changes in average temperatures with a rise in the length of the cold season no change in the length of the warm season being experienced (Nyanga *et al*. 2011). Farmers in Ethiopia have also reported a significant increase in humidity and average temperatures over the past years (Yesuf *et al*. 2008). The IPCC (2007) have pointed out that there will be a significant rise in Africa's average temperatures which will range between 0.7 and 3.5^0 C by 2050.

However, the rise in temperature will cause laziness in livestock with most of the livestock lying down on the ground most of the time (Musemwa *et al*., 2012). This will lead to a decline in the average daily weight drop compared to hurriedly consumption by animals and further lead to increases in less feed intake by livestock. Musemwa *et al* (2012) have further revealed that a rise in temperature will further lead to a reduction in animals' pulse rate. The rise in Global temperatures resulting from climate change and variability is predicted and will result in accelerating growth and developments of plants species in crop production (Thornton and Lipper, 2013). On other hand, Thornton and Lipper (2013) have observed that this climate change and variability may have two effects on agriculture, where these rising temperatures will lead to improvement in agricultural productivity (both crop and livestock) and there will be huge adverse effects on agricultural productivity on other hand which will result in declines in productivity.

Low temperatures have adverse effects on livestock production leading to metabolic responses of stimulus as a result of cold. This coldness will result in striated muscle shivers, faster heartbeat, deeper breathing, increased urine flow, sympathetic as well as pituitary controlled systems becoming activated and resulting in elevated biological oxidation which is energy expenditure for production in all tissue (Kabuga, 1992, Musemwa *et al*., 2012). This results in a surge in the cow's requirement for energy and influences reproduction of cows. According to Musemwa *et al*. (2012) low temperatures will result in the loss of mass in cattle as protein content in the veld deteriorates thus resulting in livestock experiencing insufficient amounts of low quality and indigestible feed, and this is worsened by the persistence of drought.

2.3.2 Change in precipitation

According to Solomon (2010), precipitation is the general term for rainfall and other forms of frozen or liquid water falling from clouds. Its occurrence largely depends upon the availability of appropriate temperatures and equally suitable weather conditions. It has been argued that rainfall plays a vital role in determining agricultural production compared to temperature (Lobell and Burke, 2008), but it plays a less influential role in driving year to year changes in agricultural production. The change in rainfall is one of the major noticeable climate change manifestation due to its great effect on agricultural production. South Africa is a dry country where average rainfall per annum is 500mm which ranges around 60% of the global rainfall which is 860mm per year (Krunger and Shongwe, 2004).

Blignaut *et al*. (2009) in their study mentioned that South Africa is receiving average rainfall of less than 40mm which is due to increases in temperature, which results in the reduction in rainfall which will further strain the amount of water available for the agricultural sector as well as other sectors. The South African rainfall is predicted to decline in the western part of the country where summer rainfall will decline by almost 15% while winter rainfall will decrease by 21% (Engelbrecht *et al*., 2010). These reductions in rainfall will result in negative effects, thus, threatening the agricultural sector in the future (Midgley *et al*., 2006).

However, farmers in South Africa have reported that there is a change in rainfall with an increase in rainfall delay and early cessation which brings adverse effects in farming as it delays the timing of farming and agricultural productivity (Gbetibouo, 2009, Mandleni and Anim, 2011, Gandure, 2012). Other farmers informed a reduction of rainfall during the growing season. High levels of drought are also experienced which also contributes to delays in the growing season. Abnormal intensive rainfalls which are not suitable for agricultural productivity are also being encountered.

Mertz *et al*. (2009) and Apata *et al*. (2009) outlined that West African farmers have experienced a significant delay in rainfall patterns and early cessation. These farmers have experienced a dramatic decline in rainfall. Excessive rainfall and strong winds have been encountered which influence agricultural productivity greatly and at times flooding results. These patterns have also been experienced in North Africa as well as East Africa (Yesuf *et al*., 2008) where these farmers have also experienced excessive downpour during the growing season of crops and early cessation (Juana *et al*., 2013).

2.3.3 Increase in extreme weather events.

Due to changes in climatic conditions, there has been an increase in the sum of occurrence of extreme weather events such as drought and floods throughout the country. The persistence of floods has become a vital issue in the globe as well as South Africa especially in rural areas, where it seriously damages productivity in agriculture (Juan *et al*., 2013).

Changes in climatic conditions such as extreme weather events are not the only cause to these natural events such as floods and drought but the inadequately designed settlements which make these areas vulnerable to such extreme events. Climatic models have projected that there will be a huge increase in these extreme events and average temperatures in the future because of the gaseous emissions from industries which result in destroying the ozone layer,

thus, leading to drought and flooding (Apata *et al*., 2009). These events will lead to a reduction in water available as well as stored water, which will lead the country to experience water scarcity (DST, 2010, Jha *et al*., 2011). These extreme weather events such as floods and droughts have been happening throughout the world and have damaged agriculture.

Juan *et al*. (2013), Gandure (2012) and ACCCA (2010), have outlined that farmers in Africa have agreed that extreme weather events are taking place and have experienced extended drought periods in South and East Africa which have hampered farmers negatively by reducing their productivity, bringing death in livestock and crops. The low extreme weather events lead to high fibre dietary content in livestock which limits the level of feed intake by livestock a development which will lead to animals producing less milk.

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In addition, climate change and variability is expected to increase frequency and occurrence of floods and tropical cyclones in the country which will result in infrastructure damage such as dip tanks used for dipping cattle, loss of livestock and furthermore, livestock production in South Africa as a whole. Smallholder farmers will be highly affected and disputes on livestock ownership amongst farmers will be triggered by such events. For instance, in 2010 and 2011, in Pakistan during the agricultural growing season, about 158 412 animals which were shivering as a result of floods which resulted in almost 110 million dollars (in South African currency it's almost R 1100 million) of cattle heads were lost and 2.5 million dollars (R25 million) was spent and needed for treating and vaccinating sick livestock (Musemwa *et al*., 2012). This extreme event resulted in feed shortages for livestock estimated to be worth around 1.5 million dollar (R15 million). Such events are estimated and expected to occur in South Africa as well due to fluctuations in temperatures and extreme events of climate change and variability.

2.4. Effects of climate change and variability on agricultural productivity

According to Mandleni (2011), climate change and variability is a global event, and South African is not the only country that is experiencing this event. The change in climate and variability is one of the biggest challenges the world is experiencing. South Africa is particularly vulnerable to climate change and variability as farming depends largely on the quality of the rainy season. Climate change and variability, which may make temperatures climb and reduce the rains and change their timing, may therefore put more pressure on the country's scarce water resources, with implications for agriculture, employment and food security as well as undermine sustainable development.

The effect of climate change and variability on agricultural productivity is divided into two parts, mainly effects on crop and livestock production. This is mainly due to the extent that degree of climate change and variability impact on these two products is not the same and this study is looking at both production, crop and livestock production.

2.4.1 Effects of climate change and variability on crop production

Crop production is vulnerable to climate change and variability because it does not only consider production of food consumed, but also the employment of labour that depends on it for living. The effects of climate change and variability will differ across regions, country as well as the world. These effects will result in the geographical shift of suitable land areas for the cultivation of key crops. This will not only affect crop production but will also result in increases of market prices thus a threat to consumers. Climate change and variability will result in high temperatures and water stress which will have negative effects on crop leaf formation as well as growth. This will reduce the yield of cash crops which are vital for bringing income as well as stability to rural households (USGCRP, 2009).

Yet it has direct effect on crop production under biophysical factors which include plant growth and distribution (Schmidhunuber and Tubiello, 2007). According to USGCRP (2009), despite technological innovation and improvement in crop production that increases yields, the change in climatic weather conditions and variability in long-term climatic conditions (temperature and rainfall) as well as extreme weather events has caused a great substantial decrease in yield production of crops in some years. The change in climate and variability will further result in unexpected outcomes because this effect will bring changes in crop

yields that are insufficient for crop producers as well as changes in productivity which will vary considerably across many regions of the producing areas.

However, as result of climate change and variability, there will be a net effect that will be taking place because of an increase in land areas of the higher latitudes which are suitable for crop production growth; there will be changes in seasons as there will be milder and shorter winters. There will also be a reduction in land suitability in areas such as arid and semi-arid regions which will be qualitative and quantitative respectively (AGRA, 2014). The effect in some Eastern parts of African highlands, as temperatures rise will result in suitable land turning to become unsuitable for crop growth such as wheat but more suitable for other grains that they were not planted before in that region (IPCC, 2007, FAO, 2010 and USGCRP, 2009). This effect will have a big effect on potential yields which will turn to follow the pattern of land suitability, where they will be yield gains in the middle to higher altitudes to higher latitudes and losses that are higher in the lower latitudes.

2.4.1.1 Restriction of water availability

Climate change and variability will lead to an increase in temperature which will increase the evaporation rate and decrease the amount of rainfall which will result in water shortages for crop productivity. Most of agricultural activities in the country rely on a rain fed system and this has exposed agricultural productivity due to impacts of climate change. The use of water is increasing greatly because many activities in farming require it (Blignault *et al*., 2009). According to Zhou *et al*., (2010) effects of climate change make the agricultural sector vulnerable as they result in severe droughts which hamper agriculture negatively as agricultural production requires water for growth. The dams and rivers which previously assisted in water availability will no longer be in existence due to these severe droughts which lead to a decline in agricultural production due to limited water availability for irrigation and drinkable water for livestock. This water constraint will force countries to import water from nearby country, such as Lesotho, Congo and etc. The Congo River will be used to counteract this constraint and to help in reproduction. This limitation of water will have negative implications on the economic development of the country because this constraint has lead into strategies which are very costly and capital intensive (Bilingual *et al*., 2009).

2.4.1.2 Shifts in seasons or planting dates

It has been argued that climate change and variability will bring changes in the growing season of crops because it will shift climatic conditions favourable for the growing season. As highlighted by the IPCC (2007), South Africa will be vulnerable to climate change and variability with some shifts in the seasons. According to Gray (2009), farmers have experienced some erratic and delayed rainfalls. As the rainfall comes unexpectedly in and out of these growing seasons, it has increased the length and frequency of the dry periods which affects the planting dates of crops negatively by shifting these dates.

These shifts in growing seasons have adversely affected crop production in different ways, such as stages of plant growth and development. These changes in climatic conditions have resulted in premastering flower sets which later becomes more vulnerable to chilling spells (Linderholm, 2006). The rapid rise of temperatures damages the quality of crops and fruits.

However, changes in climatic conditions have led to numerous extreme weather events like fronts occurring in major areas of the country which leads to an increasing shift the planting take as it longer to stop. These problems which are associated with climate change have resulted in farmers facing problems of changing growing dates and seasons continuously as a result of the changes in weather events (SAFWI, 2012). These changes in planting dates have subsequently affected crop production badly and have put crop farmers in an adverse situation which would have hit the planting time.

Considering the fact that most farmers depend solely on rain fed water for agricultural growth, they are at a high risk of experiencing crop failures as a result of erratic rainfalls and variations in rainfall supply (Masvaya *et al*., 2008). Farmers mostly suffer because of delayed rainfalls, thus leading to a short planting time, hence decreasing their hectrage. In this sense, crops will not have enough time to germinate, thus further decreasing crop production efficiency.

2.4.1.3 Increased incidence of diseases in crops

The change in average temperatures and rainfall as a result of climate change and variability occurrence will lead to an increase in dominance of diseases and pests in crops. USGCRP (2009) has observed that an increase in temperatures will bring benefit to the growth process of some crops but once this rise in average temperatures exceeds the required peak for crop

growth and reproduction, various challenges which are difficult for crop production arise. These difficulties include pests and diseases which affect crop growth badly in such a way that they compete with crops for growth and kill the crop. The increase in average temperatures which decreases rainfall and water availability in different parts of South Africa, will lead to a variety of pathogens, pests, earthworms and weeds in crops (South African fruit and wine initiative, 2012). The presence of such diseases on crops will increase the level of crop failures.

The effect of climate change and variability will further lead to weeds which will adversely affect the agricultural productivity as well as competing with agriculture. As a result, weeds have become more abundant as a result of climate change and variability which further results in increasing its prospect and damage on agricultural production as it will invade the establishment of habitation as result of changes in climate change and variability due to globalisation (Victoria *et al*., 2012). According to IFPRI (2009), due to wide spread of weeds, this will further result in wide spread of insect pests which will further worsen agricultural productivity and result in a decline in production. The insects or pests which carry diseases in them will escalate as result of climate change and variability leading to increased diseases in crop production and impeding the early growth of crops as well as germination stages leading to a reduction in crop production (IFPRI, 2009).

However, climate change and variability will result in pests and insects living longer than expected in crops and further result in increasing reproduction in each year which will result in increasing spread of diseases in crops in each and every new production season as well as productive areas. According to the Scottish Environmental Protection Agency (SEPA) (2013) changes in climate change and variability which make temperatures and moisture to escalate which will result in an escalating population of pests as well as increasing destruction of pests in crops.

2.4.1.4 Reduction of soil fertility

Climate change will have negative effects on soil fertility because it depends directly on climate variability to determine whether or not the soil is fertile or infertile and also in determining which agricultural activity to be practiced depends on soil fertility. The incidents of high rainfall and intensities results in high levels of leaching rates in soils that are well drainable with a high level of infiltration and furthermore result in fashionable flooding in the

soil which leads to a reduction in organic matter decomposition which helps in making soil to be fertile (FA0, 2010, IPCC, 2007). This high intensity will further give rise to greater amounts and often in water run-offs in soil and which will lead to changes in sloping terrain of soil which will further reduce soil fertility as landscape being changed by these climate changes. This change in climate conditions will make soil to be more resilient which makes the soil to have high adequate cation exchange and anion sorption which minimizes the soil nutrients loss that help the soil to be fertile for crop production which obtain nutrients from the soil through leaching these nutrients further down due to increase in humidity. Climate change effects will lead to an increase in productivity due to high temperatures and use of water economically and this will lead to a dramatic rise in ground cover which will lead to an increase in crop productivity as soil are fertile and ready for production (FAO, 2010).

The increase of average temperature and rainfall intensities will result in a rise of number of soil being accelerated which hampers the soil fertility. Climate change will result in most of the soil being wet through its high rainfall intensities which will result in mineralisation on wetter soils which will further lead to a rise in methane emissions. Further the wet soils are expected to be likely have high an N2O emission reduces soil fertility. Thus result in making crop productivity not suitable to take place and be practice (Scottish Environmental Protection Agency (SEPA, 2013).

According to FAO (2010), consequently changes in long-term climatic conditions will lead to dramatic changes in soil scenario which will result in making soil to be tough to use which leads to reduction in fertility of soil and result in making the soil more compacted to use which means will be unusable soil and infertility. The rise in average temperatures has been forecasted will result in rising numbers of glaciers in mountains and frost in soil which have negative effects on agricultural productivity as reduces soil fertility and resulting in melting ice caps which result in eroding the fertile soil away and further leads to changes in flow of water which in turn causes increase in the ecstatic sea levels which have threatens agricultural areas.

2.4.2 Outcomes of climate change on animal production

The change of climate and variability will lead to severe effects on livestock production which are unexpected results and furthermore will cause more stress on animals which will reduce animal production negatively because it reduces the alteration functions of animals.

According to Fregley (1996), the development of stress by individual animals which is acclimation which is response of such stress within the environment as they meet thermal challenges due to this stress will result in the decrease of the feed intake by animals. The decrease of the feed intake by animals is related to the impaired health and further it alters the production and reproductive efficiency of animals (Lacetera *et al*., 2003). According to Collier and Zimbelman (2007), due to high environmental temperatures which result in acclimation of animals, it involves the reaction which results to a decrease in the heat load which immediately results in the increase in respiration rates and water intake of animals and further more on this result in the changes in hormonal signals which affect the tissue response to the stimuli of the environment. This will further result in the energy that animal should take as feed intake has been reduce which will further result in the negative energy balance (NEB). As they lose this NEB it shows that animals will eventually lose their body weight and score which are of the result of the stress which is caused by high heat because of the changes in climate change and variability (Lacetera *et al*., 1996, Adams *et al*., 1998).

2.4.2.1 Reduction of feed quality

The change in climate change and variability will result in an increase in carbon dioxide which will result in an increase in the production of pasture but at the same time will result in a reduction in the quality of pastures which livestock feed on and this will also lead to the decrease in the quality of forage which is found on pastures due to high carbon dioxide (USGRP, 2009 and Field *et al*., 2007). According to Mandeni (2011), the effect of climate change and variability is more likely on the rangelands, where this effect of climate change and variability will limit the growth of plants through reduction in evapo-trasnspiration as there is a major decrease in rangeland productivity. The climate change and variability will result in an increase of CO_2 which will cause animal feed and forage that animals used to eat to become less nutritious which then will affect the quality of the livestock. This will result in farmers who grow the animal feed products to use feed additives in order to get the required growth gains in livestock and also to run away from animal illness. This effect of change variability and climate will result in an increase in the cost of growers which will in turn result in high food cost for consumers. As this change in climatic conditions will limit water availability, it means that feed availability will reduce because the nutrients required for feed is under stressed in the soil in order to keep up with plants growth (Krunger and Shongwe, 2004 and Field *et al.*, 2007).

Drought will have negative effects and pressurize the pastures and feed suppliers of livestock. This will reduce the availability of grazing land for livestock which will result in exposure of livestock to sickness and diseases because of not having quality feeding (USGCRP, 2009).

2.4.2.2 Increased incidence of diseases in Livestock

Climate change and variability have adverse effects on livestock production through increasing diseases and insects which will become more abundant as a result of changes in climatic conditions and these incidents will attack livestock and will be transmitted to livestock through vectors such as ticks and flies and farmers will find it hard to deal with as a result of increased temperature (Aydinalp and Cresser, 2008, Musemwa, *et al*., 2012) Musemwa *et al* (2012), illustrate that disease incidents in livestock will be reduced in some certain areas and different populates of the country as a result of climate change and variability. Palitza (2009) noted that climate change will raise the average temperature and in turn will spread more diseases. A noted disease is the dispersal of malaria more extensively which will affect livestock productivity through the reduction of labourers and the change of precipitation will have an adverse effect of vectors and water-borne pathogens.

It is estimated that the change in climatic conditions will encourage the increasing population of diseases to be at dispersal and these diseases will lead to adverse effect on livestock which in turn will result in high death rates by livestock as some of the diseases will be incurable and unnoticed. According to Biello (2009), there will be more diseases and insect pests which will be highly anticipated which will attack livestock productivity due to a likely increase in hotter climate conditions and humidity more especially areas that used to have temperate climate. An increase in average temperature and decline in water availability will also lead to dominance of pests which will further raise the attack of livestock by such diseases and further lead to high decline in livestock production (SAFWI, 2012). This spread of diseases will lead to an increase in the use of pesticides and fumigants which have negative effect on human health as well as livestock as the use of such fumigants will hamper the environment and result in affecting the production as well.

However, as result of spread of diseases throughout due to changing climate and variability, there will be new diseases being emerging as result of changes in weather conditions and due to high temperatures which result in increased heat stress and humidity, livestock will not fight the diseases as they are unable due to high cost of treatment. The heat waves, which are

projected to increase under climate change, will directly threaten livestock production and further result in reducing the production. Heat stress affects animals both directly and indirectly. One heat wave can directly result in death of more than 5 000 animals (FAO, 2010). Indirectly, an increase in heat waves due to climate change may increase the prevalence of parasites and diseases that affect livestock. The earlier beginning of spring and warmer winters could allow some parasites and pathogens to survive more easily (United States Climate Change Science Program, 2008).

Yet, climate change and variability will affect livestock productivity by resulting in earliest start of some seasons such as winter and spring which will permit the variety of parasites to survive early and which will have a negative impact on livestock respectively, where highly areas of rainfall they will succeed more easily to livestock more especially pathogens (USGRP 2009 and Field, *et al*., 2007).

2.4.2.3 Effect on growth performances

Climate change and variability have great influence in decreasing growth performances of livestock through changing moderate climatic conditions which are suitable for growth of livestock. According to Salem *et al.* (2011), the high temperatures as result of climate change and variability exposes livestock to such conditions which affects livestock through decreasing birth weight and survival of new-born lambs during pregnancy and late pregnancy unless there is shade provided which assist in improving birth weight and survival. This effect on growth recommends that heat stresses as result of high temperatures has an effect on uterine environment and noticeably decreases total embryo cells numbers of livestock as well as placentome size which lead to slighter sizes of livestock calves, lambs, kid, and piglets and these young ones will be more susceptible to dehydrations during the onsets and early stages of growth. Salem *et al.* (2011) and Maria *et al.* (2007) mentioned that outcomes of upsurge ambient temperatures during growth performances on livestock will be highly tempted by a decline in anabolic activities and elevated catabolism tissues. Such decline is a result of decrease in feed intake of main nutrients required on livestock for growth reasons and which are necessary. The growth performances of livestock is altering as result of climate change and variability which increases exposure of livestock to high levels of heat stresses, which result in livestock growth altering, reproduction of young ones been hugely affected and declining.

2.4.2.4 Loss of biodiversity and land degradation

The change in climate and variability will lead to exposure and sensitiveness of biodiversity among livestock as well as some crops. These changes in variability as well as climate will not stop there as these changes will lead to changes in land degradation which will hugely affect the land in such a way that will expose it to such high climatic conditions and also reduces its fertility. Land degradation is defined as the reduction in biological or economical productivity and complexity of land, resulting from land use and habitant patterns, such as soil erosion, chemical and physical properties of soil (World Meteorological Organization (WMO) 2005). Climate change and variability will lead to changes in occurrence and strength of precipitation, joined with warming temperatures and occurrence of droughts which are significant factors essential for land degradation. Elevated temperatures are likely not only to raise the decomposition rate of organic matter and organic matter loss in the soil, but also may give ascend to higher evaporation rates, leading to drier soils and more frequent episodes of severe wind erosion. It is of these reasons that climate change and variability is regarded as detrimental to land.

Climate change and variability will result in an escalating loss of vegetative cover and changes in species composition which is noted and probably the most noticeable form of land degradation and even though it is tricky to split changes in veldt due to environmental conditions. The hammering of vegetation cover and species composition is termed to as a loss of biodiversity (Meadows and Hoffman 2002). The loss of biodiversity as a result of climate change and variability will not only affect the biosphere but also the human beings who depend entirely on biodiversity as it provides food, shelter, medicines and fuels. In recent years, the African continent has experienced a significant loss of diversity and such loss is allied with and as result of climate change and variability (IPCC, 2007).

Climate change and variability has a significant impact on animals and bird species which migrate seasonally or annually within and outside Africa as result of changing climatic conditions which are suitable for such species to live under. If the climatic condition of a specific region is beyond the tolerance of the species, they are strained to migrate to a habitat that is appropriate for them. According to NEPAD (2008) outlined that since climate change and variability is a global phenomenon, even when migratory species have some capacity to change their destinations but the probability of finding sufficient suitable habitat is limited.

2.5 The possible adaptation strategies to mitigate climate change and variability on agricultural productivity

Climate change and variability has become a dominant challenge for agricultural production and rural households whose livelihoods depend solely on agriculture and natural resources. Due to unpleasant results climate change and variability brings, adaptation to climate change and variability is the only solution to minimize these effects. This section will outline and discuss the coping strategies that might be used to minimize the impacts of climate changes and variability on agricultural productivity.

2.5.1 Increasing awareness to the farmers through education

Aid agencies, have tabulated that people in developing countries such as African countries are quite aware of the climate change and variability that is actually taking place and these people have already started to adjust their farming practices to long and short-term coping strategic measures. As these farmers have already started to adjust to long and short-term farming practices, they lack knowledge of what the actual consequences that this climate change and variability entails to agricultural production as well as their production (UNFCC, 2007). Due to this lack of knowledge to smallholder farmers it is very important to make these farmers aware of climate change and variability. Further it is imperative to come up with an educational strategy which will provide small-scale farmers with the sympathetic encouragement and information which will assist in coping with climate change and variability and in implementing such methods in practise. This strategy will entail information which will contain the character of variability and climate change which will have in agricultural production as well as capability that will make peoples live much more difficult in terms of their livelihood as well as the impact this variability and climate change have in their lives and their production starting now and nearby future. So information pertaining to climate change and variability needs to be spread all over because issues related to variability and climate change are a very concerning matter. This information must also contain information regarding to options that are available to assist such farmers regarding climate change and variability effect on agricultural production. This awareness strategy through education will help in gaining information regarding the effect that variability and climate change will have as this strategy will assist in fighting and encouraging farmers to make use of other coping strategies they have used and share them among each other. This

awareness strategy can be done through media, public programs, workshops, flyers and posters.

This strategy will make sure that every farmer with regards to climate change and variability measures are made available to each smallholder farmers and this will also open up farmers mind regarding to variability and climate change issue and will make each and every population of the African continent aware of such effect and its consequences. Such educational strategies will make the smallholder farmer and those not farming to know that this is happening. People need to pay attention to TV programs which will help them to acquire knowledge on how to apply the appropriate methods necessary when faced with this kind of effect emanating from climate change and variability.

2.5.2 Increasing co-operation amongst farmers

The co-operation among farmers will help to minimize the number of small-scale farmers to manageable farmers and easy to apply measures to cope with this effect as there will be many heads to think about the situation and easy to be funded. Randela (2005) stated that the organization of farmers is vital in a way that will enable farmers in such an organization to enjoy economies of scale unlike when one is alone. That you will not be part of any such organisation will be easy to link the farmers to many opportunities that will make it easy for them to adapt to measures that will help in coping with climate change and variability. The co-operation of farmers will be important because in cases of financed and improved technology to cope with climate change and variability will be easy to be landed by government and even government to buy them such tools to cope with this effect and it will be easy to be trained on services to cope with and easily get information provided about climate change and variability and inputs to use on this regard. The formation of co-operation by smallholder farmers will help increasing access of getting credit which will use in attending workshops that will be educating them as farmers about this climate change and variability and this formation will result in easily to manage the effect and easy to implement the strategies being provide to improve their production.

Dorward *et al*. (2002) mentioned that, co-operation of farmers or organization have a crucial role in the delivery of services and co-ordination of services that small-scale farmers needs, it is easy to obtain them and this services that will help to cope with such effect that is being posed by climate change and variability. This co-operation will help the farmers to cope with

this effect and to increase their production which will help in facilitating agricultural products which will help in bringing cost of such product down.

According to Walker (2005), the use training by farmers will enable the farmers to be trained in a variety of skills which will include the skill of transferable information, technology and skills which will be on great use in fighting the variability and climate change on agricultural production which will be easy to conduct than when there are individual small-scale farmers this is easily done when smallholder farmer form co-operatives. The use of such co-operation will also be helpful in decision making also encourage the farmers the essential thinking skill that will obtain by joining co-operation and learning that will be made on these co-operation.

2.5.3 Innovative Agricultural Practices and Technology

The new agricultural practices as well as techniques and new technology will be of much use in helping farmers to cope and finding solutions on climate change and variability in agricultural production. Victoria *et al* (2012) mentioned that the key contributor to agricultural emission of carbon is erosion, which will result in the reduction of agricultural tillage which stands to be much of the vital improvement in agricultural practice over conventional practices. This strategy will be the key one in such a way that it will lead to farmers easily coping with such effects and also increasing their production because they will use new production techniques such as GM crops and bio-fuels which will offer easy adaptation to climate change and variability effect. Callaway (2004) tabulated that, crops that present tolerance to drought, heat and early maturation tend to decrease the risk of extreme temperatures and rays a farmer might face due to such effects of climate change and variability in agricultural production. This strategy will involve practices which will encourage crops and livestock diversification, make use of drought-tolerant varieties of crops and livestock types, mixed of agricultural productivity and rotational credit (Mandleni, 2012).

2.5.4 Agro forestry

This is one of the adaptation and mitigation synergies which must be used to cope with climate change and variability effect in agricultural production. Agro-forestry first is the combination of agriculture and forestry which is known as having high potential in sequestering the carbon as one of coping strategy (FAO, 2010a). This strategy of agro-forestry contributes provision of environmental services which will help in coping with such effects of variability and climate change through diversified tree products, protected soil

health and enriched animal feeds. Accordance to FAO (2010a), trees have a crucial and very vital role they play in reducing vulnerability and also have the strength of increasing the farming system too and it also has an important buffering it offers to households and farmers in coping and protecting against risks related to variability and climate change. The growing of trees in farms will have a major boost and important role in improving the soil conditions and also provide the crops with shade and livestock as climate change and variability will pose too much heat. The products it produces besides vital for income, it is also important in scattering risks in situation where livestock and crops have failed due to diseases posed by variability and climate change.

According to Dube *et al* (2005) mentioned that, other coping strategies such agro forestry make use of forest products as a defence to induce variability and climate change effect in crop failure in agricultural production areas. ECA (2001) noted that, some areas have improved their coping strategy by making use of fertiliser techniques to twofold trees density, which is vital in holding soil together and reverses the diversification in agricultural production.

2.5.5 Changing the timing of operations

One of the most important mitigation measures which must be used to counteract with climate change and variability is the changing time of planting and operation in the farm level which largely involves altering the timing of farm activities which will suit climatic changes (Smit and Skinner, 2002). Smit and Skinner (2002) mentioned that this operation measure involves the scheduling of agricultural productivity activities which are growing dates, irrigation, harvesting and grazing. This can be put into practice by farmers changing their growing dates which will enable a variety of crops to be grown in different times of the year which enables farmers to harvest in different planted time (Lasco *et al*., 2011). The change in time operation by farmers has a potential to improve and maximize agricultural productivity during the growing season and also assist in avoiding the heat stresses and moisture deficiencies in agricultural productivity, especially livestock production (Smit and Skinner, 2002).

2.5.6 Change crop and livestock varieties

Another strategy which must be used to mitigate and minimize climate change and variability on agricultural productivity is the use of changing crop and livestock varieties which are

being used. Lasco *et al*. (2011) mentioned that this strategy involves the changing either fro crop or livestock varieties to other varieties in response to climate change and variability. This will solely be done by adopting climatic tough livestock or crops varieties which are able to endure changes in climate conditions and stresses. Smith *et al.* (1996) has outlined that this strategy has a huge potential to raise and improve the level of efficiency in the farm in light of climate change and variability. Some farmers in counteracting with these changes are now growing many crops in one area while other areas must grow either early and late the maturing varieties of the same crop which ensures that at least grown crops will produce large harvest (Action Aid, 2008).

2.5.7 Diversification of income-generating and livelihoods activities

Many people on the African continent, especially South Africa and the emerging farmers solely depend on agricultural activities for their livelihoods, which are affected by this climate change and variability negatively. The negative effect of climate change and variability has resulted in shifting their mind and daily work to non-agricultural activities in an attempt to avoid such huge losses from climatic conditions that are changing (Lasco *et al*., 2011). Lasco *et al.* (2011) have outlined that there is an increase of raising livestock and reap in most of surrounding areas in an attempt to alleviate income generated from crop production by emerging farmers as well as commercial farmers as a result of stresses caused by climate change and variability. According to studies made and researches conducted in Africa, many farmers have diversified their income generated from their livelihoods by growing vegetables and fruits before and after some crop productions been cultivated (Oxfam, 2009) where the produce from such planted fruits and vegetables supplements the food supply of farm household and other is sold to markets.

2.5.8 Change in current farm management practices

Lasco *et al*. (2011) observed that the altering of farm management practices is one of the mitigating strategies to decrease agricultural vulnerability to climate change and variability. It makes use of management of the soil, land, water, as well as management at the farm level and irrigation. FAO (2007) have illustrated that the efficient use and management of land and soil will and normally improves the ability of crops to tolerate the excess water owing to high intensity precipitation and a lack of water as result of extended dry periods. Therefore FAO (2007) has suggested that such effects can be rectified by improving the soil organic matter in

the course of practising conservation and organic agriculture as they promote low tillage and soil maintenance cover. The use of soil organic matter does assist by allowing the soil to confine and preserve large amounts of water which assists in decreasing the susceptibility of crops to tremendous climate scenario and will further regulate the soil wearing away and surface run-offs (Muller, 2009).

Lybbert and Sumner (2010) mentioned that the use of irrigation schemes has improved agricultural productivity by farmers greatly. Due to the already increasing urban, rural and environmental demand for water, tied by altering climatic conditions especial intensifying average temperatures and diminishing rainfall, agriculture must greatly improve the water use more efficiently. Farmers both commercial and emerging ones will have to use irrigation schemes which are more water efficient and only apply irrigation measures when it's necessary. Further, governments in developing countries, especially in Africa must intervene because farmers in the continent are desperately in need of techniques, technologies and investments that will assist in improving water management more efficiency, access to irrigation or to find ways of advances in income levels with less secure and more variable water availability.

2.5.9 Development of new varieties

Lybbert and Sumner (2010) stated that the stakeholders, government officials and non-government organisations must increase their investments on agricultural research with the view to assist in the development of new crop species and varieties which are resistant to extreme weather events, pests and diseases as well as early maturation which will assist in shortening the growing season of crops. The use and development of genetically modified organisms (GMOs) has increased the production yield and agriculture has largely benefited with such use in recent years and even now still benefiting on GMOs (FAO, 2003). The use of such crops will assist in mitigating the climate change and variability and will give improvement in varieties of agricultural productivity which will be produced at an increasing rate and will further assist in the development of other crop varieties with the assistance from genetic engineers than use the natural and conversional methods. According to Thomson (2008) and Thomas (2008), the use of GMOs has increased and improved crop production worldwide and South Africa and their use has increased at a rapid rate as a result of resistance to pests and diseases as well as increasing yields and the common GM crops are namely; maize, cotton, soybeans.

However, the use of GMOs will not only assist in increasing yields but will also reduce the adverse effects caused by pesticides and insecticides which are used to kill pests but have high negative effects on the environment and human health. According to FAO (2003), this will help farmers in such a way that they will no longer make use of such anti-pest fumigants in their crops as it will assist farmers in producing their fumigants such as insecticides themselves. The use of GMOs and the development of crop varieties will reduce the level of variability of farmers in South Africa as well as in the African continent and further improve their production and income levels which have been hugely declining.

2.5.10 Shades and Ventilation

The availability of shades and ventilation will play a vital role in protecting agricultural productivity against variation in climatic conditions. The availability of this strategy will assist farmers in providing them with shades and ventilation during times of high average temperatures and precipitation for the poor farmers who cannot afford to purchase expensive materials to build houses and class houses for protection (Musemwa *et al*., 2012). The availability of trees in the farm will assist the farmers in providing them with shade which is natural. Musemwa *et al*. (2012) outlined that there is no difference between natural and artificial shade and ventilation in terms of protecting livestock. The availability of trees is excellent because these are the excellent protector for any activity in the farm, especially paturates and they assist in cooling the surroundings. The availability of shades reduces the amount of heat caused by climate change and variability, and is essential in reducing heat levels and stress in livestock and also protecting crops from being eroded by dangerous winds.

2.5.11 Advances in access to weather forecast and focus information

According to Musemwa *et al*. (2012), the low agricultural based information provided among farmers is one of the vital factors which have limited agricultural development. The delivering of information is very decisive in enhancing capacities of farmers, especially farmers in rural areas. The lack of information delivery in farmers about climate change and variability is the reason that most farmers in Africa, especially South African rural areas have low ability to adapt to climate change and variability because of lack of timorous and reliable information on weather information, adaptive strategies as well as new technologies which are used to withstand this effect. The improvement in early warning systems and weather

forecast system circulation accesses will play a crucial role in informing farmers (Thomton *et al*., 2007). The uses of such improved systems and weather forecast will have optimistic outlooks which will notify how much time we have prior to the onset of such events and will assist in organizing the intervention mechanisms to be applied and be put in place.

However, Musemwa *et al*. (2012) mentioned that by making information on weather events available to farmers, it will enable agricultural production movements in time. While many stakeholders have considered a progress in provided communication system such as extension services, cell phone, newspapers, most of the farmers in rural areas and developing countries still remained uninformed of such weather forecasts as they used outdated equipment for their farming and probabilities of prediction. Their outdated prediction probability makes farmers not to believe in such instances.

According to Musemwa *et al*. (2012), the use of radios, pamphlets, internet, televisions and other media are still used for weather focus although access by farmers is still limited to farmers and most of the information is transmitted and written in English of which farmers do not understand. This information is therefore irrelevant to the majority of farmers who understand only their mother tongue. The stakeholders must improve such transmition of information to farmers in greater use and make sure that all languages are used in broadcasting the information is used more widely.

2.5.12 Crop and Livestock Insurance

Agricultural productivity is a major part of farming which plays a crucial role in stock markets and human lives. Crop and livestock insurance is one of the strategies that can assist farmers in coping with climate change and variability (Ngigi, 2009). The reason for such insurance in livestock and crops is due to the fact that some crops and livestock species are more consistent than others and more important in human's life as well as a country's economy. According to Ngigi (2009) and IFPRI (2009) climate change and variability will lead to too many incidents of crop and livestock failure. This development is prevalent in smallholder farmers than commercial farmers, so the creation of insurance for crop and livestock by government and lending facilities will assist these farmers against climate change and variability phenomena such as disasters, floods, drought where farmers have little defence on extreme weather events. The crop and livestock insurance will assist and serve as a barrier against climate change and variability and will offer the farmers with the crucial

support arrangement which will be necessary in steering up some uncertain climatic future forecast and events as well as to evade the financial loss and damage (Ngigi, 2009).

2.5.13 Make use of local breeds

The use of local breeds will be helpful in the sense that they are easily adaptive to harsh conditions. Since the country is characterised by lack of technology in farming, especially smallholder farmers in breeding of livestock, this strategy will assist in adapting to climate change and variability and will catalyse the process to be faster (Musemwa *et al*., 2012). According to Musemwa *et al*. (2012), most of the farming of livestock makes use of exotic breeds which have a large body size but more vulnerable to climate change and variability and are easily exposed to harsh conditions resulting in such livestock not being able to cope with climate change. Farmers who are using exotic breeds are facing high production costs as a result of climate change and variability which exposes such breeds. The use of local breeds such as Nguni cattle which are more adaptive to harsh conditions as they have been living in such surrounding areas for thousands of years can lower the effects of climate change and variability on livestock production.

The adaptation strategy of using local breeds is not only for tolerance of heat but this mitigation strategy is for the survival, reproduction and growth of livestock in such environment which contains deprived diet for livestock, diseases, lice and poor forage (IFAD, 2010). This coping strategy will strengthen the resistance of livestock to ticks and protection to tick borne diseases as well as helping in fertility of livestock production. The local breeds will assist in mitigating this climate change and variability since they have low ratio of mortality and incidents of disease occurrence (Muchenje *et al.* 2008, Musemwa *et al*. 2012). According to Muchenje *et al.* (2008), the use of local breeds like the Nguni which is more resistant to climatic conditions which are changing because it carries lowest tick numbers on itself and is more resistance. Nguni breed can survive with or without dipping or dosing as these exotic breeds cannot survive instead die (Tshiala and Olwoch, 2010). The productivity of local breeds is not affected by changes in climatic conditions compared to other breeds such as exotic ones. For example, the Bonsmara drop their growth rate as well as live weight extensively due climate changes and variability. According to Musemwa *et al*. (2010), these local breeds are highly adaptable to deprived grazing quality and to an environment of extreme heat and humidity. These local breeds have adaptive traits such as walking ability

which enables them to walk long distances in search for water and grazing pastures and they can leaf through in steep slopes and bulky bushes.

2.7 Summary

Climate change and variability is no longer a projection and doubt issue anymore but is a global problem and phenomenon because it does not only affect countries with and which produces high greenhouse gas emission but instead the world as a whole. Agriculture is one of the most affected and exposed sectors by climate change and variability because of its dependency on climate conditions and resources which are sensitive climate change and variability. Climate change and variability brings adverse effects which influences agricultural productivity mostly negatively although it has little positives. Smallholder farmers who dominate the agricultural sector in developing countries throughout the world, especially South Africa are the most vulnerable to climate change and variability because they solely depends on rain fed water for irrigation and agricultural production. With climate change and variability projections indicating that, amount of rainfall will continue to decline now and in the near future while average temperature are likely to continue to climb and rise which will accelerate food insecurity problem which already manifest itself in many developing countries, especially South Africa where is already high and it means it will double the already existing percentage of food insecurity and poverty rates (FAO, 2010).

The impact of these adverse climate changes and variability on agriculture is exacerbated in developing countries, especially the African continent in particular, which is hampered by a lack of adapting strategies to changes in climate and variability which are restricted due to lack of institutional, economic and financial capacity to support such activities. The application of these strategies will help in improving agricultural productivity as well as in minimizing the effect of climate change and variability. Some of the strategies are costly which will require government intervention in helping these farmers in adopting it and employing these mitigation strategies and train them. Therefore, Africa's vulnerability to climate change and variability as well as its failure to adapt to these changes has overwhelming results to agricultural sector, which is the main source of livelihoods to the majority of the population and source of living.

The paramount concern must be a better understanding of the potential impact of the current and projected climate change and variability on agricultural productivity and to recognize

ways and means to adapt and mitigate climate change and variability detrimental impacts on agricultural productivity. No single country acting on its own would be able to significantly influence the effects and causes of climate change and variability. Policies addressing climate change and variability will have an environmental, political, economic and social impact on all countries and will require action by all countries. Even though funding is necessary, it is not an adequate component in lucratively addressing the variability and climate change effects on agricultural productivity as well as adaptation. Therefore feasible institutions and effective policy frameworks at the national and global level needs to be established and strengthened in order to improve adaptive capacity of farmers and also mitigate climate change and variability in Africa, especially South Africa.

CHAPTER THREE

APPROACH AND RESEARCH METHODS OF THE STUDY

3.1 Introduction

This chapter will justify the selection of study area and research methods which were used in this study. The selection of the study area on the population, geographic information, socio-economic viewpoint, topography and climate and vegetation. The research methodology outlines the research methods that the study used in collecting and analysing data. This section describes the study area, sampling procedure and sampling frame, how data was collected and analysed.

3.2 Description and selection of the study area

Description of the study area illustrates the background information of the King Sabata Dalindyebo (KSD) Local Municipality. It outlines the geographical location, climatic conditions, agricultural activities and topography of the study area. Description of the study is helpful as it familiarizes one with the study area where the research was based on and gives description of the KSD Local Municipality.

3.2.1 Geographical location

King Sabata Dalindyebo Local Municipality was established in December 2000 and KSD Local Municipality comprises of two magistrate areas which are Mtata and Mqanduli. KSD is one of the 7 Local Municipalities, located under the O.R Tambo District Municipality in the Eastern Cape (King Sabata Dalindyebo Local Municipality, 2009). The name KSD was chosen from King Sabata Dalindyebo who fought for freedom in Transkei. KSD Local Municipality is located in the Eastern Cape which is the second largest province of South Africa and is the poorest province in the country, (see figure 3.1 which shows Eastern Cape Province) as well as respective Municipalities. KSD Local Municipality has a total population of around 451 710 and the majority of whom reside in rural settlements where rural household size is 105 240 (King Sabtha Dalindyebo Municipality, 2010). According to King Sabata Dalindyebo Municipality (2009), the municipality comprises of 105 000 households with an average of 4 to 7 people per household and it measures nearly 3 027 km^2 which is 1 169 sq mi in extent. The municipality comprises of 35 wards, of which 12 wards

are rural based. The municipality has low diversity which is 96% Blacks and 1.7% Coloureds, 2% Whites and 1.3% Indians. Agriculture, tourism and forestry are the 3 main economic opportunities offering hope for development in this municipality. The major language which is widely spoken in this municipality is IsiXhosa at 92.8 %, English 3.6 % and other languages at 3.6 % respectively. The population of the municipality is 0.82 % per annum. The major challenge of the municipality is unemployment, which is sitting at 38.30 % (Stats SA, 2013).

Most areas of King Sabata Dalindyebo Local Municipality are located in the grassland biome while there are great forestation plantation areas in the Municipality especially when you move to the north side of the Municipality. The Municipality is altering with large ecological areas as it has moved from indigenous forestry (Natural forestry that exists) to well plantated forestry (Man made forests) which has taken a large sum.

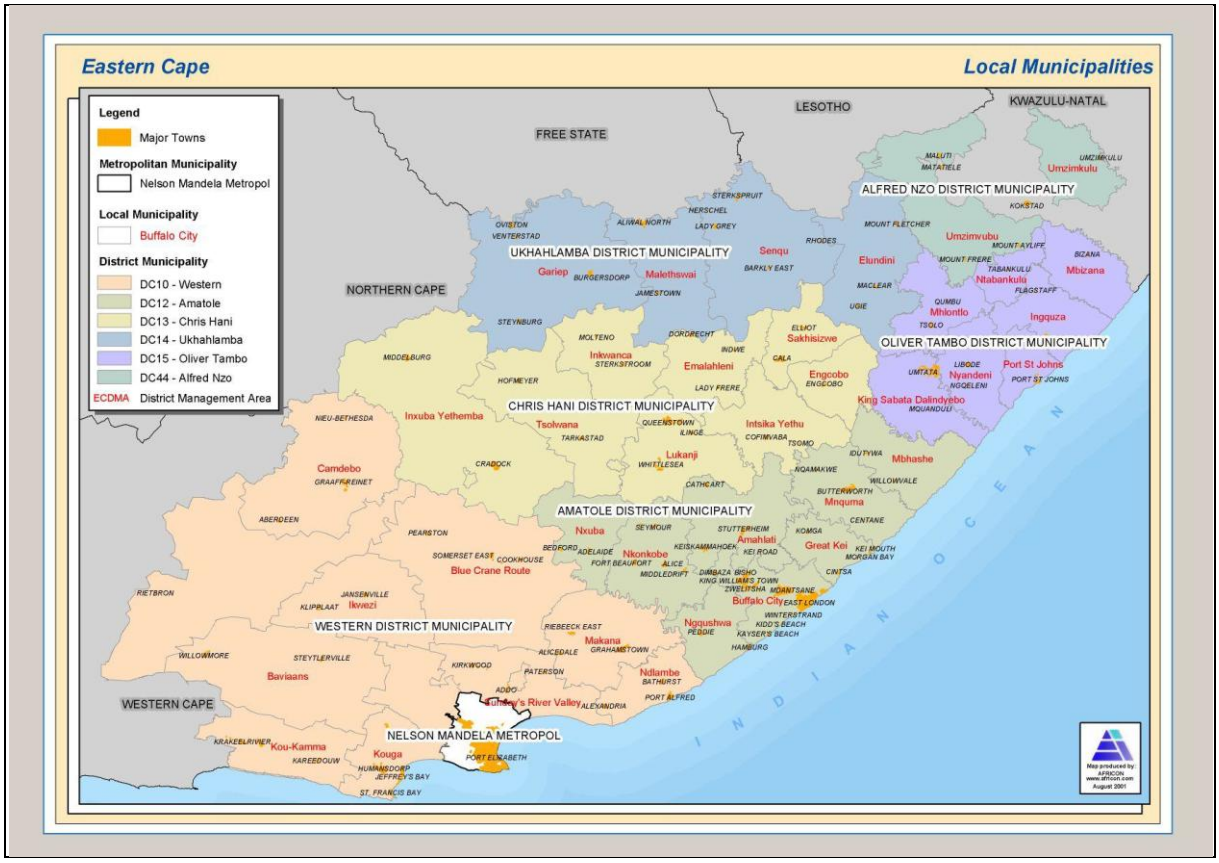

Figure 3.1: Map showing district municipalities of the Eastern Cape Province and King Sabata Dalindyebo municipality

(Source: ECDC, 2013)

3.2.2 Socio economic viewpoint

King Sabata Dalindyebo Local Municipality (2009) has outlined that the municipality has a major stumbling block which is poverty. The average poverty rate ranges more than 70% and HDI (Human Development Index) is 0.50% compared to the national average of 0.653, where employed people are estimated to be above 26% and most of these people are employed in community based centres and services. It is further estimated by the King Sabata Dalindyebo Local Municipality (2009) and Smit (2003) that 34%-36% of households solely depend on social security where they solely earn R1 280 and almost 85% earn less than R 1000 per month. King Sabata Dalindyebo Municipality (2010), mentioned that the child support grant in the municipality is approximately 70%. The infrastructural development in the municipality is poor and lacking, and the number of households with piped water and taps is limited. Almost half of the Municipality does not have clean water, low access to electricity, and no wastage removal. The infrastructure used is old and outdated which makes the situation even worse. The level of education in the municipality is increasing at a low rate compared to other years. The rate of people with tertiary education is increasing by 2% per year and almost more than 40% do not have education at all.

This raise of 2% per year of people going to tertiary's in KSD municipality is assisting the municipality in terms of acquiring formal education which will increase skills and knowledge in the municipality as well as improving agricultural productivity through skills obtained in tertiary's. Furthermore, the major reason for 40% not to have education at all is due to a high unemployment rate as most households solely depend on social grants. They heavily depend on social grants which play an important role in this municipality and agricultural production as they use social grants as their source of credit to purchase inputs and pay labour which improves agricultural productivity.

3.2.3 Topography and climate

The municipality is composed of grassland vegetation which is thick and moist upland. The veld of the municipality is grassland and the veld is dominated by pioneer grasses. It has a clear stream which is suitable and clear of vegetation and is composed of steep banks towards the Mtata River which is unreachable by animals and crop farmers (Smit, 2003). The grassland vegetation the municipality has plays an important role in improving productivity.

KSD Local Municipality has warm temperatures and the municipality often receives its rainfall in summer and spring. It often receives heavy thunderstorms and short intensity rainfalls which in turn have negative impacts to crop and livestock production (River Health Programme, 2008). According to King Sabata Dalindyebo Local Municipality (2009), KSD local municipality normally receives an average rainfall of 584mm per annum, with most rainfall received during the summer. It receives the lowest rainfall (7mm) in June and the highest (89mm) in March. Its average mid-day temperatures range from 18 ^{0}C in July to 25.5°C in February. The study area is selected because of a large number of rural households and some smallholder farmers whose livelihoods depend on agricultural production. Also, agriculture is one of the main economic opportunities that are active in promoting hope for development in this local municipality.

In Y-axis in the first graph illustrate rainfall in mm while in the second graph the y-axis is the average mid-day temperatures that are been experienced in King Sabata Dalindyebo Municipality.

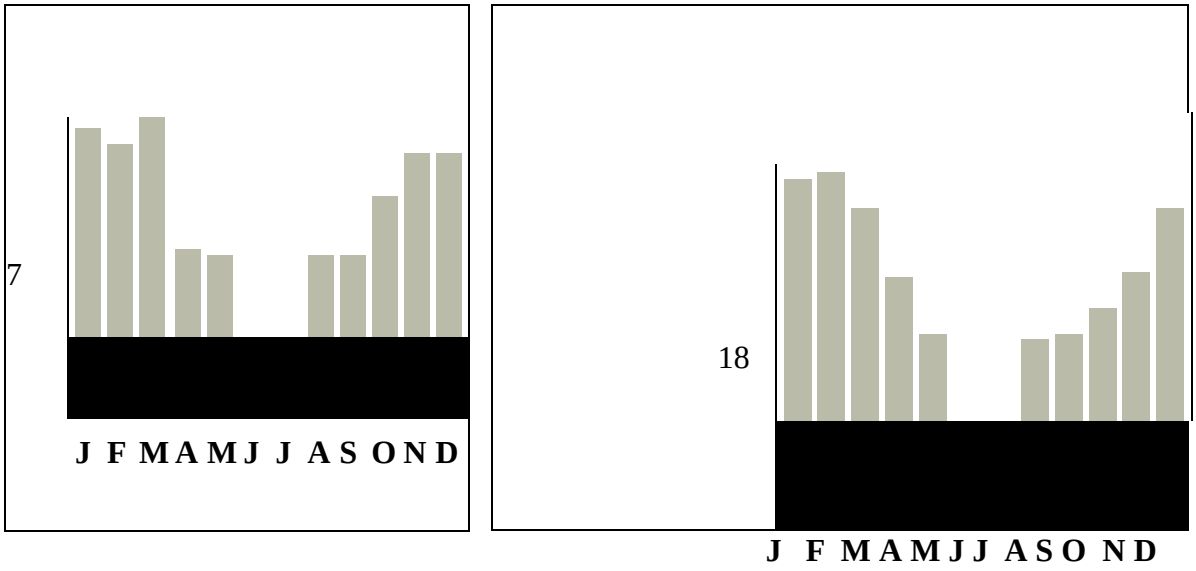

Figure 3.2: Climatic conditions of KSD Minicipality

Source: King Sabata Dalindyebo Municipality, 2010

3.2.4 Agricultural potential

King Sabata Dalindyebo Municipality has varied climatic conditions throughout the year and topography where Mqanduli region is a tropical region while Mtata is a temperate climate region which plays important role and contributes to diversity of agricultural production in the municipality which includes bee keeping, beef farming, dairy farming, crop farming, wool farming, forestry and fishing, tropical and deciduous fruit farming, vegetable farming and it is excellent tourism region (King Sabata Dalindyebo Municipality, 2010). The KSD Municipality is comprised of smallholder land use farming which is widely associated with clearing of natural vegetation for agricultural based activities such as crop and livestock farming as well as veld burning for grazing purposes which occur with no formal control. The land which farmers have access to is communal based land which is normally used for agricultural activities and forestry.

As much as the municipality has varied climatic conditions, climate change and variability will change these climatic conditions positively or negatively which will consequently affects agricultural potential in the municipality. Climate change and variability will change suitable places for growing certain crop to a crop which was suitable in such region as well as changing habitation on crops and livestock species.

Methodology

3.3 Research design and Conceptual framework

This section presents the study research design and conceptual framework used in the study as well as explaining them.

3.3.1 Research design

This study employed a cross-sectional research design. Data was collected at one point in time on several variables such as demographics, household and farmer socio-economic factors, market potential, farmer awareness on climate change and variability, access to extension services and effect of climate change and variability on agricultural productivity. Only a subset to represent the population thereof was selected. Both qualitative and quantitative data was gathered on demographics, household socio-economic factors, market

potential and farmers' awareness and effect of climate change and variability on agricultural productivity. The study was carried out in two phases: orientation and a survey during the 2013/2014 farming seasons.

3.3.2 Conceptual framework

The below conceptual framework presented in figure 3.3 below illustrates the linkages between climatic variables, agricultural productivity, coping strategies and lastly, policy framework and institutions. Climate change and variability (change in temperatures and rainfall patterns, extreme weather events) leads to exposure and sensitivity of agricultural productivity which ultimately results to potential effects which adversely affects agricultural productivity, farmers' livelihood patterns and self-directed mitigation strategies by farmers. The framework further illustrates the importance of adaptation strategies in reducing the potential effects of climate change and variability on agricultural productivity.

The Framework further illustrates how policies and institutions influence in adaptation measures which were planned measures to lead to an effect and vulnerabilities of agricultural productivity. These mitigation measures which were planned measures, do play a crucial role in reducing vulnerability of farmers' and households to climate change and variability as it builds flexibility to climate extremes through the adoption of improved technologies.

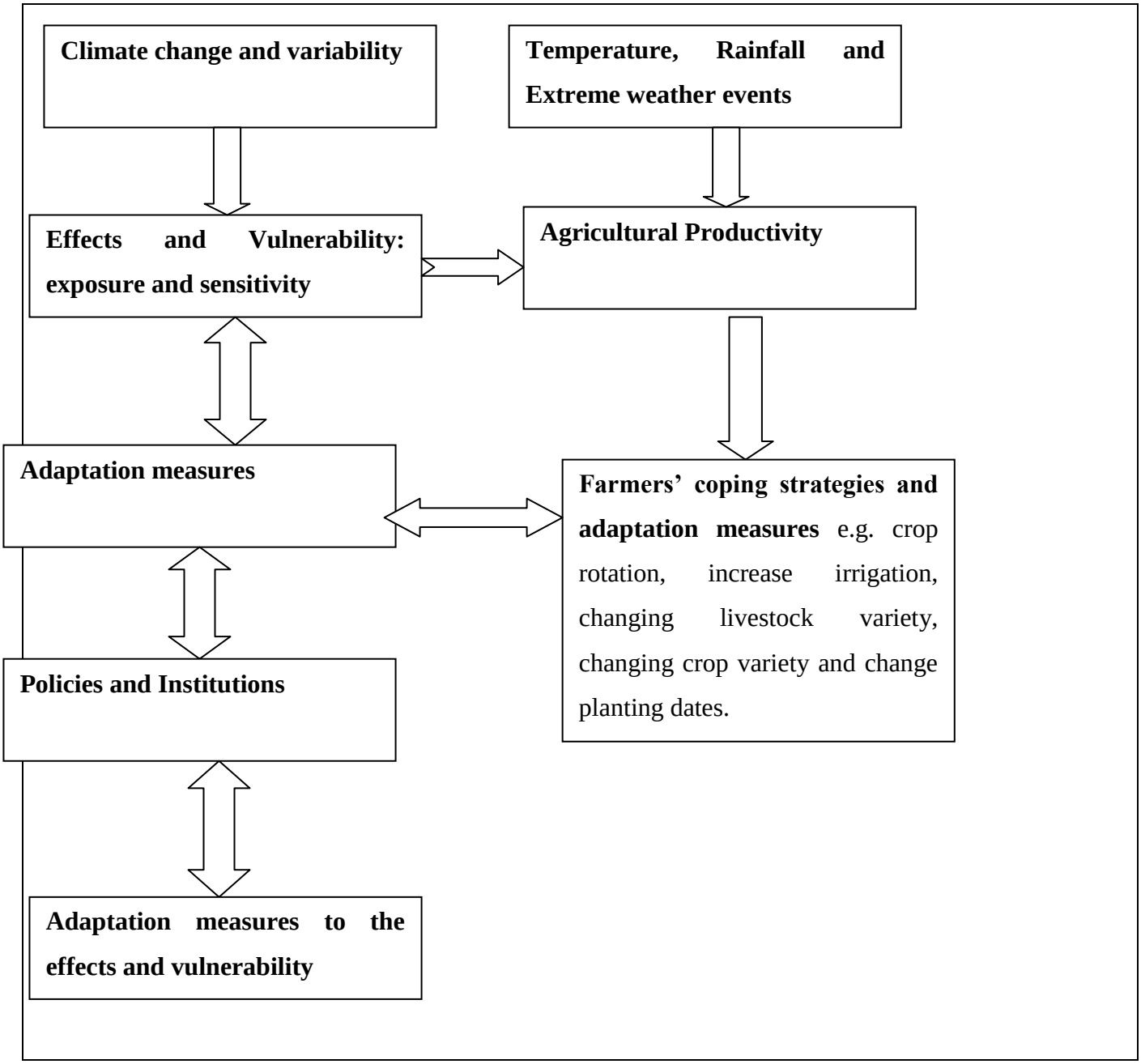

Figure 3.3: Conceptual framework (**Source:** Modified from OKUMU, 2013)

3.4 Sampling Procedure

Sampling is a process of selecting units from a population of interest so that, by studying the sample, the results obtained from the sample may be generalized to the population from which the sample had been chosen (Leedy and Ormrod, 2004). There are two types of sampling methods which are non-probability and probability sampling procedures. The probability sampling procedure allows for the possibility of including each element of the

population which can be determined, whereas non- probability sampling refers to the possibility of including each element of the population in a sample is unknown (Bless and Smith, 2006).

A multi-stage sampling was used in which the first stage involved selecting respondents from wards of King Sabata Dalindyebo Municipality. This was done through stratification by separating farmers in terms of their wards and communities. This was followed by employing quota sampling through the census statistics to determine farmers who were practicing crop, livestock and mixed farmers in King Sabata Dalindyebo Municipality. Lastly random sampling was used to get the sample size for the study. Selection of farmers through the use of random sampling was based on participation in agriculture through crop, livestock and mixed farming as well as willingness to participate on the research. All farmers willing to participate and practice crop, livestock and mixed farming, were interviewed. During the data collection process, the participants were told the objective of the study as well as the confidentiality of the study. Interviews were done at farmers' homesteads and at community halls. Farmers were interviewed individually and were heads.

The main data for this study were based on a sample of 200 farmers from King Sabata Dalindyebo Municipality. The Wards chosen captures variability in a wide range of agro-climate conditions (rainfall, temperatures and soils), market characteristics (market accessibility, infrastructure etc) and agricultural diversity among other factors. Detailed information from the Department of agriculture and Farm Management Handbook was used to guide identification of agro-ecological zones and farm types (Jaetzold, R. and Schidt, H., 1982).

3.5 Sources of climate Information

To achieve the objectives of the study, the study made use of both primary and secondary data. Primary data was collected using questionnaires from farmers while secondary data was temperature and rainfall figures of the past 30 to 50 years for the selected study area, water flow and production.

3.5.1 Primary data

Primary data collection always involves the trade-off between undertaking an intensive study in a small geographical area versus a broader examination of a larger area. In attempting to

balance the requirement for capturing important details and unlimited applicability, both quantitative and qualitative research approach were used in this research as a questionnaire is designed as a tool for data collection (as noted by Fidzani *et al* (1993)). According to Leedy (1994), the most important guideline for questionnaire construction is to inspect the assumptions underlying the question.

There are different ways in which a questionnaire may be administered. These include the self-administered questionnaire, face-to-face interview and telephone survey. Face-to-face interviews were considered the relevant method for data collection in this study. The following guidelines as proposed by Babbie (2001) were considered prior to the implementation of this survey:

- Appearance and demeanour of the interviewers;
- Familiarity with the questionnaire;
- Following questionnaire wording exactly;
- Recording responses exactly; and
- Probing for response.

Respondents were selected based on practising and involved in agricultural activities. Their willingness to participate in the research was also given high priority in selecting respondents. Respondents were told the objective of the study and were further informed about the confidentiality of the study during the data collection process before being interviewed. Structured, interviewer-administered questionnaires were used to acquire information about farmers' perceptions regarding the effects of climate change and variability on agricultural productivity and coping strategies used by farmers to cope and adapt to climate change and variability. The questionnaires were interviewer-administered so as to ease problems of misinterpretations or misunderstandings of words or questions. The use of interviewer-administered questionnaires was to ensure that information was obtained from illiterate respondents.

The questionnaire was composed of closed ended questions to make the coding of the responses easier and to extract as much information as possible from the respondents without taking too much of their time.

3.5.2 Secondary data

In addition, secondary data was collected from municipal offices and the internet. Secondary data on farmers' awareness on climate change and variability and coping strategies employed by farmers KSD Municipality in the Eastern Cape Province of South Africa.

For this study, temperature and rainfall figures of the past 30 to 50 years for the selected study area were obtained from the South African Weather Services (SAWS). Data on crops yield, tons, production and percentage area planted for the past 30 to 50 years was obtained from the National Department of Agriculture (NDA). The water flow of King Sabata Dalindyebo Municipality was obtained from Department of Water Affairs.

In addition library based research was conducted in order to explore what other researchers have done in the same field. Sources of such information include journals, books, internet, and government documents.

3.6 Surveys

Surveys involved the actual data collection on smallholder farmers. This was conducted by means of an interview schedule (questionnaire) as the data collection instrument. A structured questionnaire was used to collect data from respondents as to standardize the order in which questions were asked to respondents, and to ensure that questions were answered within the same context.

3.7 Sampling frame and size

When sampling, it is important to deal with an adequate sample size in order to collect accurate information about a group (Bless and Higson, 1995). A large sample is more representative but very costly; while a small sample is less accurate but more convenient. The survey was targeting a suitable sample size for farmers in the selected study areas. The sample size was 200 farmers. The 200 farmers which the study made use of crop farmers, livestock farmers and farmers who are practising both farming. The smallholder farmers were selected from King Sabata Dalindyebo Municipality as a whole which were composed of mainly crop and livestock farmers based on farmers' willingness to participate on this research. A sample size of 200 farmers was constructed.

3.8 Data collection and instruments

There were several types of data that were collected from respondents. Both quantitative and qualitative data was used, but mostly this study focused on quantitative data. A questionnaire was used as an instrument for data collection and the required information was gathered through face to face interviews and secondary data from Department of Weather Services. In this study self-administered questionnaires were used. The required information includes personal information (such as age, gender, level of education and marital status), general demographic data (income levels, household size, crops grown and livestock kept), climate variables, water flow and type of soils.

The study applied quantitative methods of data collection by visiting smallholder farmers producing crops, livestock and mixed crop-livestock farming to investigate farmers' awareness of climate change and variability. Database of smallholder farmers from King Sabata Dalindyebo Local Municipality was used to access the smallholder farmers producing crop, livestock and mixed farming.

To measure the effect of climate change and variability on agricultural productivity a household survey was conducted in the smallholder farming sector where crops, livestock and mixed crop-livestock farmers were interviewed. The majority of households in King Sabata Dalindyebo Local Municipality were smallholder farmers producing crops, livestock and mixed crop and livestock farming. To ensure that there was sufficient coverage in the data collected a stratification method was used to separate farmers.

3.9 Data analysis

After collecting and gathering data, it was captured and encoded in the form of spreadsheets in Microsoft Excel and exported to SPSS software. The study made use of descriptive statistics, Binary regression and Ricardian Model in analyzing the data collected. To determine to what extent smallholder farmers were aware of climate changes and variability, descriptive statistics which made use of mean, frequencies was used. Descriptive statistics was also used for interpretation of household demographics and socio-economic factors and variables that were likely to influence the adaptation measures to mitigate climate change. Interpretive analysis used was simple statistics, tables, pie charts and graphs were used. Binary regression approach was applied to test farmers' awareness of climate change and variability. Ricardian Model analysis was applied to assess and test how changes and

variability in climate affects farm income. Descriptive statistics was used and applied in testing the coping strategies used by farmers' in King Sabata Dalindyebo municipality in coping with climate change and variability.

3.9.1 Descriptive statistics

Descriptive statistics is defined as a set of brief descriptive coefficients that summarizes a given set of data, which can either be an illustration of the entire population or a sample. Measures that descriptive statistics uses to describe the data set were measures of central tendency and measures of variability or dispersion, where by measures of central tendency comprises of mean, median and mode, while measures of variability consist of the standard deviation, the minimum and maximum variables and skewness (Gujarati, 1992). Descriptive statistics grants a useful summary of safety returns when performing empirical and analytical analysis (Mcata, 2012). Mostly the descriptive statistics were commonly used to describe the basic features of the data in a study. It provides simple summaries about the sample and the measures (Research Methods Knowledge Base, 2008). Descriptive statistics uses graphical and numerical summaries to give a 'picture' of a data set (Research Methods Knowledge Base, 2008).

The descriptive statistics tool was used to analyse and describe farmers' awareness of climate change and variability on agricultural production. Descriptive statistics was further applied to describe the coping strategies used by farmers to cope with climate change and variability effects.

3.9.2 Binary Regression Model

The study utilized a binary logistic model to analyze factors that influence farmers' awareness on climate change. Binary logistic regression is a type of regression analysis where the dependent variable is a dummy variable (coded 0, 1). The logistic regression model is simply a non-linear transformation of the linear regression. The logistic distribution is an S-shaped distribution function (cumulative density function) which is similar to the standard normal distribution and constrains the estimated probabilities to lie between 0 and 1. The dependent variable was coded 0 if the farmer was not aware of climate change and 1 Otherwise. According to Greene (2003) the logit model takes the form:

$$\log(P_i\ /(1 - P_i)\ = logP_i = \beta_0 + \beta_1 X_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (1)$$

Where P_i is the probability of being aware of climate change and X_1 is a predictor variable. Therefore the parameter β_0 gives the odds ratio of the dependent variable.

The probability of the occurrence of an event relative to non-occurrence is called the odds ratio and given by the following equation:

$$P_i \ /(1 - P_i) \ = \exp(\beta_0 + \beta_1 X_1) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . (2)$$

Or in terms of probability outcomes

$$P_i = \exp(\beta_0 + \beta_1 X_1)/(1 + exp(\beta_0 + \beta_1 X_1)) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (3)$$

The model is set as follows

$$P_I = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots . \beta_n + \mu_i \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (4)$$

Where: β_0=intercept term

$\beta_1, \beta_2, \beta_3 \dots \beta_n$= slope of the parameters or regression coefficients of the model which measures a unit change in explanatory variables.

X_1, $X_2 \dots . X_n$ = Explanatory or independent variables or factors that explain awareness of climate change or the probability that a farmer is aware of climate change.
U_i = Error or disturbance term

The model was estimated to identify the farmers' awareness of climate change on agricultural productivity.

3.9.3 Ricardian model

Ricardian model is an econometric model which is mostly used to analyse the relationship between agricultural productivity and climate through regressing sets of climate variables such as temperatures and rainfall as well as other socio-economic variables with farm revenue obtained from agricultural productivity. According to Mendelssohn *et al*., (1994) mentioned that the use of the Ricardian analysis is to measure the contribution of each of the independent variables to the outcome of agricultural productivity and climate change effects on agriculture.

This technique has been named Ricardian method because it was based on the surveillance completed by Ricardo (1817), where he stated that land values would reveal land productivity

at the site under perfect competition. The model has been found attractive because it corrects bias in the production function approach by using economic data on the land value.

The study adopted a cross-sectional (Ricardian) approach to measure the impacts of climate change and variability on farm revenue, which allows the farmers to capture adaptations in making response to climate change and variation as the cross sectional approach applied to agricultural. According to Mendelson *et al.* (2000), the Ricardian model has one disadvantage which is the assumption that prices are constant even though it is more difficult to handle price effects properly in any of the other methods. It measures the impact of climate change and variability attributes (rainfall and temperature levels) on farm income from all agricultural production systems (crop, livestock and mixed), controlling for other production factors. Based on empirical estimates from the Ricardian model, future impacts under various climate scenarios were predicted. In addition to estimating impacts on crop farms, impacts on specialized farms were also measured and compared. Responses of different production systems were analyzed under irrigation and dry-land conditions in studies conducted in Africa, South Africa and Sri lanka.

In the Ricardian model, net revenue or capitalized net revenue (land value (V)) accounts for the costs and benefits of adaptation. Direct measurement of farm prices or revenues allows the Ricardian approach to account for the direct impacts of climate on yields of different crops, as well as the indirect substitution of different activities and other potential adaptations to different climates (Mendelsohn *et al*., 1994). A number of variables – climatic, soil, socioeconomic and hydrological were examined to determine the effects of climate and variability on farmland. The standard Ricardian model relies on a quadratic formulation of climatic variables:

$$V = ß_0 + ß_1F + ß_2F\,2 + ß_3Z + ß_4G + ß_5\log(H) + u$$

Where,

V = Farmland value (reflects the present value of future net productivity).

F = Climate variables (temperature and precipitation)

Z = Set of soil variables

G = Set of economic variables

H = Set of hydrological variables (water flow used as a log form because the benefits from flow diminish as flow increases).

u = Error term.

To capture the non-linear relationship between net farm revenues and climate variables, the estimation includes both the linear and quadratic terms for the climate variables, F (temperature and precipitation) (Mendelsohn & Dinar, 2003). A negative quadratic term reflects an inverted U-shaped relationship between net farm revenue and the climate variable and a positive quadratic term means a U-shaped relationship (Mendelsohn & Dinar, 2003). Net farm revenue is expected to have an inverted U-shaped relationship with temperature. According to Kurukulasuriya *et al*. (2006), water flow is introduced in a log form because the benefits from flow diminish as flow increases. Water flowwas used as a proxy for the hydrological variable (H). Water flow was included because it is particularly important for irrigation (Mendelsohn & Dinar 2003).

3.9.3.1 Data to be used in the model

Generally, the Ricardian model is a regression model and estimate the impacts of the explanatory variables (seasonal climate variables, soils, water flow and socio-economic factors) on farm net revenues.

3.9.3.2 Total net farm revenue

The study made use of total net farm revenue as the measure of farm performance (an approach close to that used by Kurukulasuriya *et al*., 2006). Total net farm revenue is defined as the sum of net revenues from three main farming activities: (1) dry-land crops, (2) irrigated crops, and (3) livestock. Farm net revenue (R) was assumed to reflect the present value of future net productivity and costs of individual crops and livestock. In this study, crop net revenue was the gross revenue less costs of fertilizer and pesticide, hired labour (valued at the median market wage rate), transport, packaging and marketing, storage and post-harvest losses. Livestock net revenue was the gross revenue from livestock sales less costs of livestock production.

3.9.3.3 Climate variables (temperature and precipitation)

The study was relying on long-term average climate (normals) for districts in the Eastern Cape Province. Such data was gathered from South African weather stations or from the Eastern Cape Government Department of Agriculture. The temperature and precipitation data cover slightly different seasons. This discrepancy may be a problem for measuring variance or higher moments of the climate distribution, but it should not affect the use of the mean of the distribution (Kurukulasuriya *et al*., 2006). Monthly temperature and precipitation data in the Ricardian regression model is not self-evident (Nhemachena, 2009) and correlation is too high between adjacent months, therefore temperature and precipitation data are grouped into three month average seasons (winter, spring, summer and fall).

3.9.3.4 Water Flow

The mean water flow variable (long run flow in m^3) had been shown by empirical studies to be significant in determining the impacts of additional water sources on net farm revenue. According to Nhemachena (2009) water flow had a significant positive effect on the total and mixed crop-livestock farms. Kurukulasuriya and Mendelsohn (2007) also found that water flow strongly influences net farm revenue, especially for irrigated farms. Using irrigation appears to positively influence net farm revenue for all farm types, except specialized livestock farms. The possible explanation was that during the dry season water flow provides water for livestock watering and irrigation systems.

3.9.3.5 Socio-economic factors

Socio-economic factors included in the empirical model were household ownership of farm assets (farmland, tractors); household access to agricultural extension services; household size; and technology variables (household access to electricity; household access to tractors and irrigation technologies). Dummy variables were used here for example household ownership of farm assets (such as tractors) (yes (1) no (2)).

The dependent variable for the Ricardian model is Farm income per ha of agricultural productivity. The independent variables which made up quadratic and linear terms of rainfall and temperatures as well as socio-economic characteristics of the farm and types of soils. Farm revue is the product of total harvest of agricultural productivity (crops and livestock)

and prices of livestock and crops which are totally associated cost of production calculated for each agricultural household.

3.9.3.6 Soil variables

Soil types had shown to be significant by empirical models (Nhemachena, 2009). In this study four soil types were entered:

1) JcMFU (calcaricfluvisols)

2) lcU (chromic luvisols)

3) lfCU (ferric luvisols)

4) qlCU (luvicarenosols)

The arenosols are extensively developed and are usually high productivity soils. Fluvisols and luvisols are also identified as high productivity soils. The chromic luvisols will be considered as unproductive soils.

3.10 Summary

The study was conducted in King Sabata Dalindyebo Local Municipality in the Eastern Cape Province. The primary data was collected using a questionnaire while secondary data was obtained from satellite and artes. Descriptive statistics, Binary logistic model and Ricardian model were the models applied in this study where descriptive statistics was used in testing farmers' perceptions regarding to climate change and variability as well as the coping strategies been used by farmers in mitigating climate change and variability. The descriptive statistics was also applied on basic characteristics of sampled farmers in KSD Municipality. The binary linear regression model was applied in testing farmers' awareness of climate change and variability. The Ricardian and Binary regression model was applied in testing the effect of climate change and variability on agricultural productivity in terms of farm land value or income while binary regression was applied in testing farmer's awareness.

CHAPTER FOUR

DESCRIPTIVE RESULTS, ANALYSIS AND DISCUSSIONS

4.1 Introduction

This chapter is a presentation of the general characteristics and profiled sampled farmers using descriptive analysis and the profile is based on collected data from respondents. The household demographic characteristics (gender, age, marital status, level of education, household size, employment status, household source of income and other characteristics that were described and included in the study were analysed), socio-economic characteristics (access to credit, access to extension services, access to markets and farmer organization), cropping and livestock farming, the farmers' awareness of climate change and variability on agricultural production, changes noticed by farmers as result of climate change and variability on agricultural productivity. Full explanation upon the characteristics stated above was done and literature was also consulted in order to check if the results attained agree with what is in the literature. Mitigating climate change and variability will, in turn, increase agricultural yields, increase market off take thereby increasing household income earnings and farmers standards of living of the beneficiaries of improved agricultural production programmes.

The aim of this chapter was to highlight the various factors affecting smallholder farmers' awareness and highlighting the conditions that exist in sampled areas. The demographic characteristics, socio-economic factors as well as climate change and variability variables were explained using descriptive statistics, such as: mean values, frequencies, percentages, tables, bar graphs as well as pie charts. The variables discussed in this chapter try to provide a clear understanding and picture on farmers' awareness of climate change and variability on smallholder farmers in King Sabata Dalindyebo Municipality in the Eastern Cape.

4.2 Demographic characteristics of study household

Demographic characteristics of farmers and households are essential when analysing economic data because such factors influence the households' economic behaviour. As mentioned in Chapter Three, the study sample consisted of 200 farmers. In accordance of Bembridge (1987), household demographical information is based on the characteristics of individuals within that particular household that describes the epidemiology used to characterize the population at risk. Therefore, the study examined the farmers in terms of

gender, marital status, age, level of education, household size, household source of income, number of people who are working and those who are not employed. All this demographic information will be discussed below using descriptive analysis which was used in tables, bar graphs and pie charts. The descriptive statistics will be used to test and describe the farmers' awareness of climate change and variability on agricultural production as well as analysing the coping strategies used by farmers to cope with climate change and variability. These tests from descriptive statistics about farmers' awareness and coping strategies were analysed using charts, graphs and tables.

4.3 Household information

4.3.1 Gender

The gender distribution of households is very vital for various reasons such as decision taken in resource allocation as there are gender differences into the extent to which female and male volunteers take to risks and become tolerant enough to any kind of uncertain outcomes that may arise. It is also crucial in the magnitude that there are implications involved of the present and past socio-economic factors and standards which will employ a lot of impact on decisions to adopt new practices to enhance sustainability and profitability of the farm. The figure below is summarizing the gender distribution of the interviewed smallholder farmers in the King Sabata Dalindyebo Municipality.

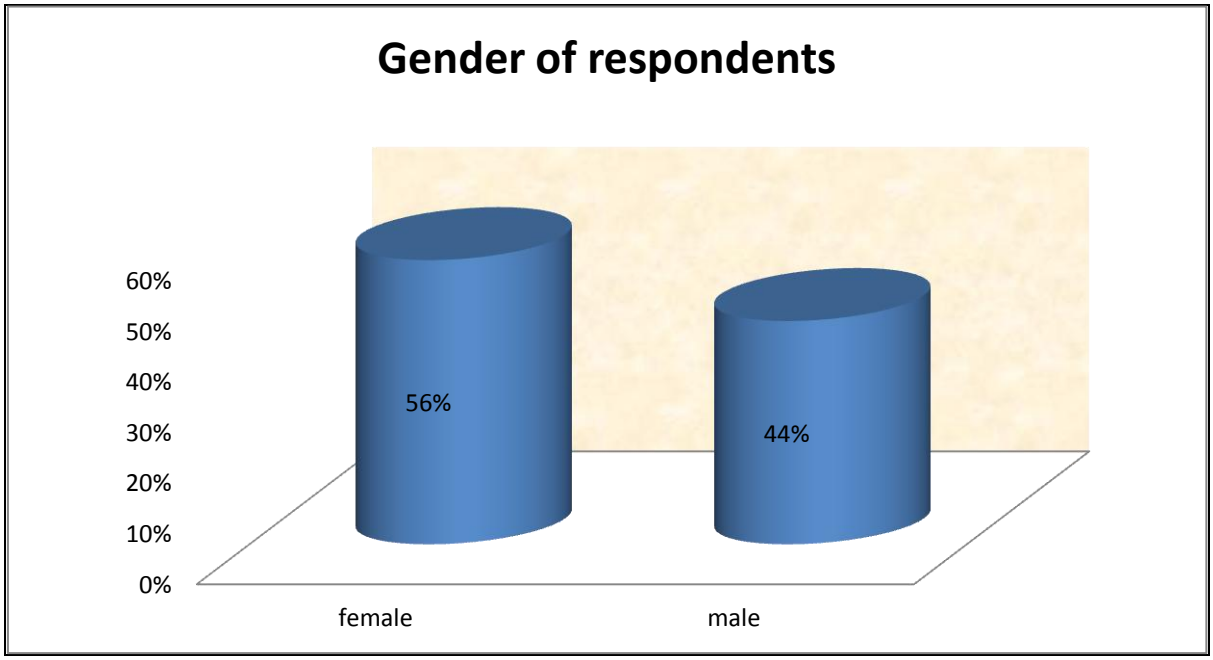

Figure 4.1: Gender distribution of respondents **Source:** Field Survey, 2014

Figure 4.1 above shows gender distribution of the farmers which was drawn from the sample of 200 farmers interviewed. From the data collected, the majority of farmers are female headed. This is represented by percentage distribution which is 56% to female farmers' to 44% to male farmers. These results are in line with the assumption that most rural households and farmers are headed by females as males migrate to cities to look for work. Therefore, this means that females are more dominant in farming than men as shown by the results in figure 4.1 above. This is because women spend entirely and most of their times taking care of the family while men go to urban areas to search for better employment and living opportunities.

According to Mcata (2013), women play an important role in agriculture as most of women in rural areas of South Africa are food producers rather than mens. The results states that females in the sampled study are more dominant in agriculture and are practicing agricultural production than men as shown by the results in the figure. This dominance of women in agriculture in the municipality is attributed to the fact that women spend much of their time taking care of family while men migrate and go to urban areas in search of work and better employment opportunities. This result is consistent with the findings of Mcata (2012) who stated that, females in South Africa play an important role in improving agricultural productivity through producing food rather than men. The dominance of women's in agriculture in KSD will play a crucial role in adopting new improved adaptation strategies that will assist in coping and mitigating climate change and variability than male farmers.

These results agrees with Nassif (2008) findings female farmers are likely to adapt easily to climate change and variability by allowing the development and consolidation of new practices in dealing with climate change and variability on agricultural productivity.

4.3.2 Age

Age is an essential aspect because it shows whether households benefit from the experience of older people or has to base its decision on the risk taking attitude of younger farmers (Muchara, 2011). The farmers' age is not only important for experience but is also crucial aspect in agricultural productivity as it assist in determining the experience of the farmer, knowledge as well as physical environment. The pie chart below is summarizing the age distribution of sampled smallholder farmers in KSD.

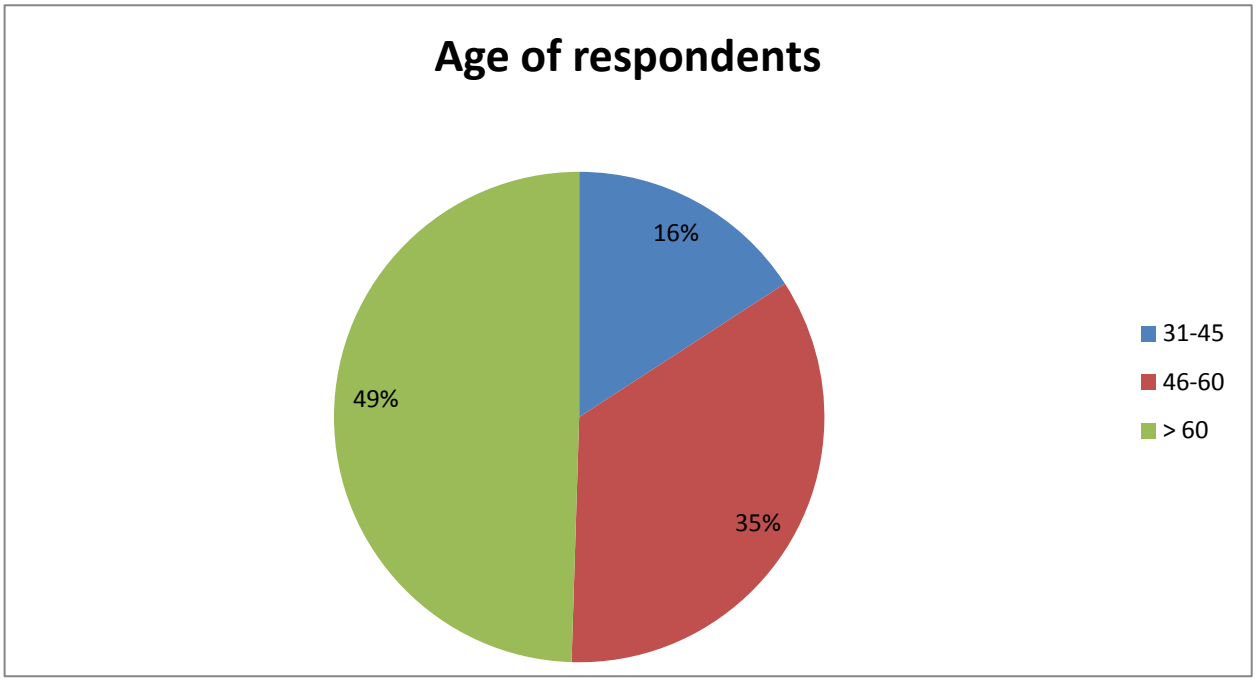

Figure 1.2: Age distribution of respondents **Source:** Field survey, 2014.

In this study, there were four age groups used which were 18-30 years, 31-45 years, 46-60 years and >60 years. Figure 4.2 above outlines that there is no one participating in agricultural sector between the age group of 18-30 years while the youngest head of the household ranges from 31-45 years with a constitution of 16% and the study further found out that about 35% of household heads at an age of 46-60 years. The oldest age group from the sample that partakes in the agricultural sector is above 60 years old about 50%. According to Muchara (2011) the age of the household head is very important and plays a vital role because it reflects whether the household is benefiting from the experience that the elderly person bears.

These results prove that the elderly people are the ones dominating the agricultural sector and they are the ones participating in agriculture compared to young people who are migrating to urban areas. This is likely to enhance household food security status because elderly people are more experienced with agricultural practices and have inherited the knowledge from their forefathers and grand grandfathers. This is supported and proven by Sikwela (2008), who indicated that there is a positive correlation between age and own food production. The age of the household head can be also used as a proxy of explaining farmers experience in farming and also used as proxy for explaining farmers experience in practising agricultural productivity. The age of farmers can be used to explain the decline in agricultural productivity in the municipality.

Those who were partaking in agricultural production in the municipality were mostly (50%) elderly people (above 60 years) in comparison to youngsters. This is supported by Sikwela (2008) who stated that there is positive correlation between own production which improves agricultural production and age.

These results have indirect bearing on the availability of ablebodied manpower for agricultural production and influences adoption rate of climate change adaptation strategies due to elderly people who partakes in agriculture. Also, age influences the ability to seek and obtain off-farm jobs and income, which could increase farmers' income and could help cope with adverse change in climate.

4.3.3 Marital status

According to Zenda (2002) and Mcata (2012) married households are able to diversify and share household activities (such as agricultural production, harvesting, fetching water, ploughing and herding livestock) among themselves. While it is stipulated that single, widowed and divorcees households heads found it difficult to share the activities as they all do the household activities by themselves as they do not have all the necessary support, unless they acquire some assistance from older children who are fit enough to assist with household activities. Married households are the ones who are more committed to agriculture than those single, divorced and windowed households due to result of the heavier load for family support than married household have on their shoulder (Mcata, 2012). In most of the African families, the priorities and stability of a household is usually judged based on the marital status and it is further believed that married farmers tend to be more stable in farming activities than unmarried heads.

The married households are the ones who improve agricultural productivity than divorced, single and widowed households as they have load of support from the family. This means that there are more labourers available to assist and improve productivity compared to singled, widowed and divorced households.

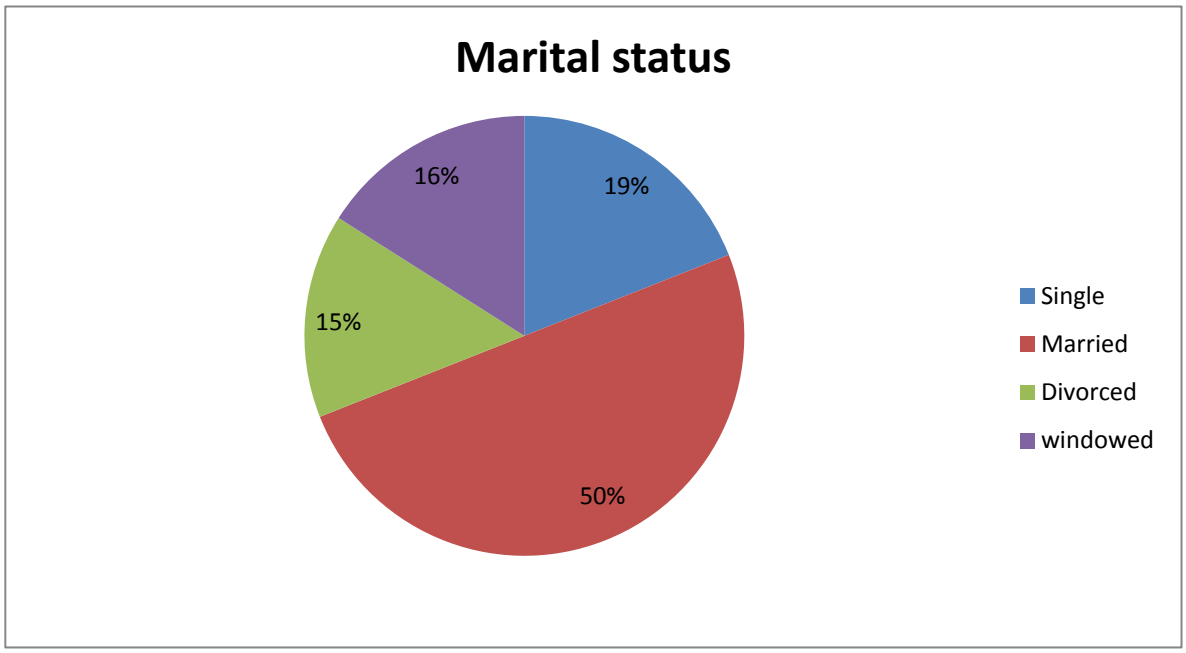

Figure 4.3: Marital status of respondents **Source**: Field survey, 2014

The marital status of the farmers is presented in Figure 4.3 and shows that the majority of farmers are married. This is illustrated with 19% of single farmers, 15% divorced farmers and 16% windowed farmers while the remaining 50% is occupied by married farmers. Therefore, as argued by Mcata (2012), these farmers which are married are at an advantage and can own farm because they have partners which can help and assist them in farming and agricultural sector. A married farmer tends to be less likely to be vulnerable to food insecurity and labour shortage than single, separated and divorced farmers. The trends in marital status of farmers' head are very precarious in African societies, where it assists in determining stability of families. According to Musemwa (2008) married farmers tend to be steadier and established in farming activities than unmarried farmers, and thus have an impact on both agricultural production and marketing outlines. Nevertheless, further scrutiny of the connection between marital status and farmers' partaking in agricultural activities is required.

Therefore, as argued by Mcata (2012), the married households are at an advantage and they can improve agricultural productivity because they have partners and labour from their children to help them with agricultural production. The single households headed families that are the second largest group practicing agriculture and improving agricultural productivity, they are followed by widowed households and finally divorced households. Households with married people tend to increase their productivity through the assistance of

their partners and children which makes them less likely to be vulnerable to low agricultural production and food production than single, widowed and divorced households.

4.3.4 Level of education

The level of education is vital because literacy which is obtained through education had been noted as one of the factors which enables farmers a chance to obtain as well as process applicable information (Sibanda, 2012). It is also anticipated that the level of education does play a crucial role in influencing the adoption level of new innovations by farmers as well as translated to the human capital as well as the aptitude to deal with modern farm decision making processes. The households who had obtained education and have higher levels of education are the households which are able to interpret information as well as writing (Muchara, 2011). The level of education for this particular research ranges from tertiary, secondary, primary and other levels of education one can have.

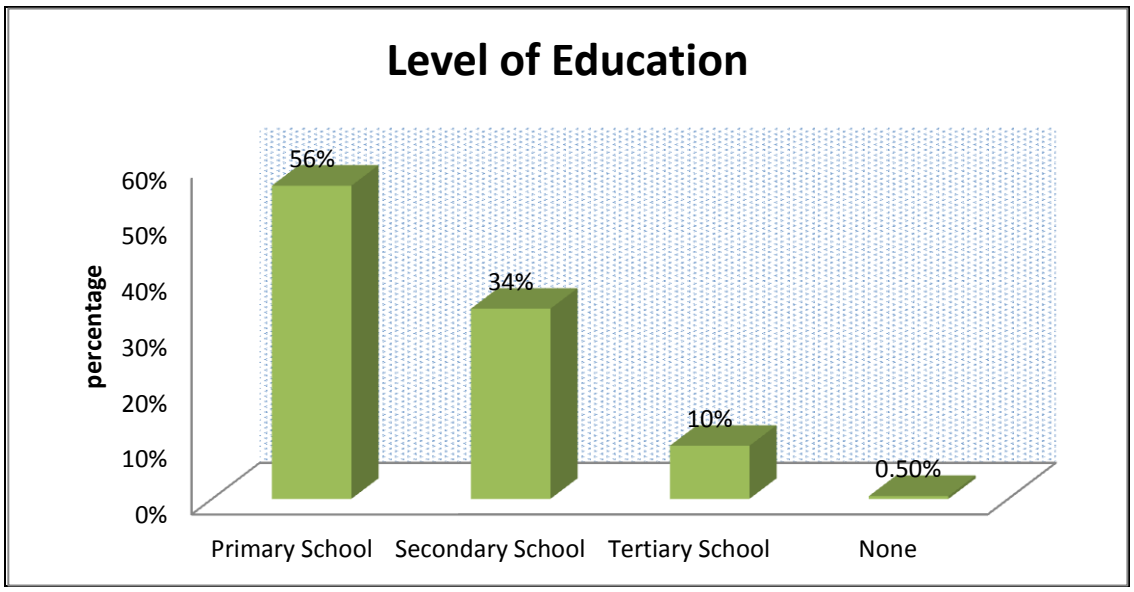

Figure 4.4: Level of Education of respondents **Source:** Field survey, 2014

Figure 4.4 shows the educational level of the interviewed farmers of KSD Municipality. Figure 4.4 displays that farmers that attained secondary education make up the second largest group of educated farmers with 34%, followed by those with a tertiary qualification with 10% and finally those who did not attend school with 0.50%. Primary education is the highest level of education attained by farmers in KSD Municipality with 56%. The results indicate that there is a low margin of people in the municipality who undergo tertiary school to further their studies and acquire more skills and knowledge as revealed by the minimal figure of 10%

of the people having tertiary qualifications. The low marginal number of people with higher education might have been influenced by the movement of people away from agriculture into industry as they acquire more education. Lack of professional skills can also be linked to the employment levels in the communities and municipality as whole.

The high levels of the lack of formal education which are prevalent in KSD Municipality is consistent with the literature which states that people who reside in rural areas tend to be less educated than those in urban areas, due to the demographic location of the schools. According to Musemwa (2008) the level of uneducated farmers is expected to decrease over the coming years as there is a rise in the level of education in rural areas as many rural dwellers have access to education which is increasing and will improve living standards and farming sectors in rural areas. Many of the present farmers' heads are elderly and youth of today will have significantly more basic education by the time they become household and farmers' head as the youths have a better access to education nowadays than before. However problems may arise as most of the youths may be employed in the formal sector and other informal sectors as most of them view agriculture as a dirty business and pension zone.

Thus, knowledge does contribute to the agricultural sector and farming since better educated people are able to use their knowledge in improving agricultural production and increasing yields. It is concluded that those households and farmers with family members who went to school are the ones who are at an advantage and understand the information given to them, especially when it is written in their own language. Further, they know the importance of partaking in the agricultural sector as a means to supplementing the household food basket. A number of studies have dealt with the education system in South Africa and most findings suggest that the lack of education maybe be contributing to the limited participation in agriculture by rural based people.

A study by Maddison (2007) stressed that educated and experienced farmers are expected to have more knowledge and information about climate change to use in response to climate challenges. The education level of farmers will have significance impact in dealing with climate change and variability, as it will increase knowledge of farmers about climate change and variability as well as increases ideas in coping with climate change and variability on agricultural productivity.

This study has revealed that most of the farmers are illiterate and level of illiterate in the municipality is high among the respondents and this could have implication for agricultural production and also for adaptation to climate change and variability. Furthermore, this high rate of illiterate farmers could have implications for adoption of measures that could result in climate change adaptation is also easier and faster among the educated farmers than the uneducated farmers.

4.3.5 Household size

This study considered household size as the number of individuals who reside in the respondent's household. Mcata (2012) and Hayes *et al.* (1997) indicated that a large household size means that there is an increased labour capacity available in the form of elderly, middle aged and young members. There is comprehensive evidence to the effect that household size has a high influence on the marketing of agricultural productivity as it plays a huge role in affecting consumption and production levels (Randela, 2005). Household size does have an important role on both in the production and consumption as it assists in terms of work from the start till the end of the value chain.

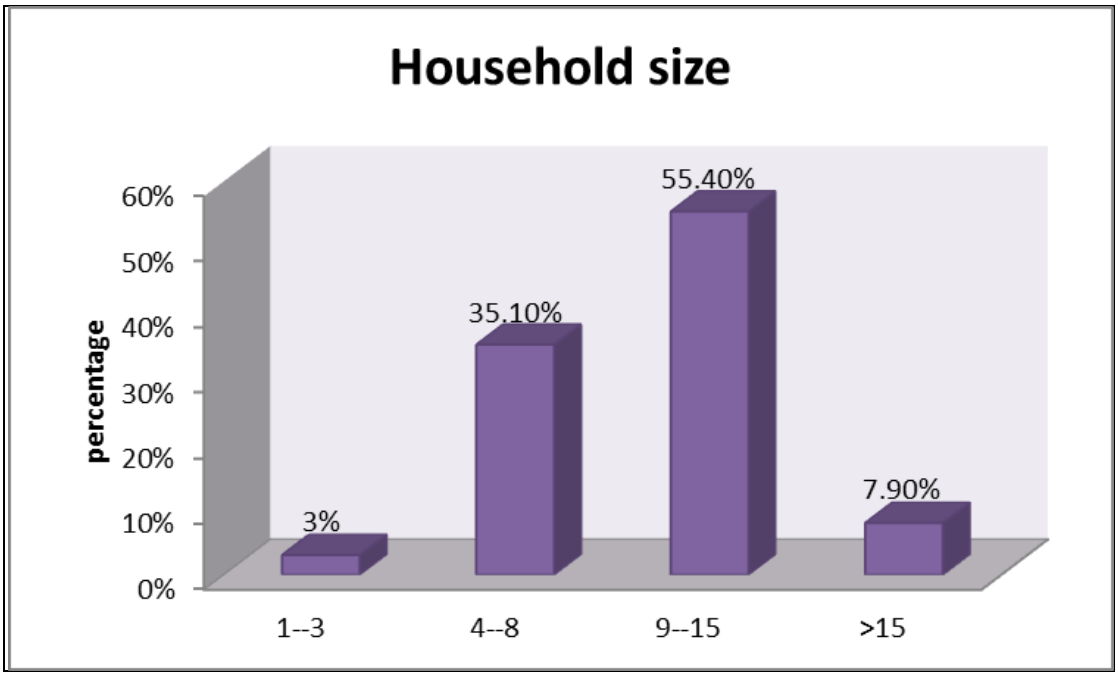

Figure 4.5: Household size of the respondents **Source:** Field survey, 2014

The results in the figure 4.5 above illustrate that there is a small margin of farmers with 1-3 household size which is 3%. This is followed by farmers with a household size of >15 which is 7.90%. The study reveals that the household size with 4-8 members and 9-15 members are

the most dominant household sizes that are partaking in the agricultural sector with 35.10% and 55.40% respectively. Having large household size is a benefit for the farmer in terms of labour availability. According to Sikwela (2008) without any doubt, household size can be used as a proxy for labour availability from young, middle and elderly members.

This implies that households and farmers would not have serious difficulties with regard to labour, which ultimately means and suggests that there would be more people to assist with farming which will in turn provide food to households. Generally, the results show that most of the households are large hence there is more labour available for farming. According to Paddy (2003), larger families with big household size can also be vulnerable to food insecurity due to a greater demand for food other than assisting with labour availability.

The results suggest that large household size will assist in providing labour for the households which will play a key role in improving agricultural productivity as there will be enough people to assist in farming, thus increase production levels of food. The low household size will reduce labour which will have adverse effects on agricultural productivity compared to a large household size.

4.3.6 Employment status

The world is faced with a high unemployment rate and IPA [undated] suggests that most of the world's poor households sorely depend on agriculture for their source of livelihoods as well as income. Kekana (2006) argued that there is a rapid growth of unemployment and poverty rates occurring ever since the available employment opportunities especially in rural areas fails to keep up with the growing population the world is facing, especially Africa. So partaking in farming by households does not only provide food but also generates employment as well as income for rural dwellers (Koyenikan, 2007).

Figure 4.6: Employment status of respondents **Source:** Field survey, 2014

Figure 4.6 above illustrates the employment status of sampled respondents. The results confirm that the levels of education have shown that as the municipality is faced with high uneducated levels, this has resulted in many people in KSD being unemployed at 68.30% as they have primary education as well as having low skills. However, there are a certain percentage of people in the municipality who are employed with 31.70%. The level of unemployed villagers (68.30%) shows a need for labour intensive projects in the communities to absorb the surplus labour. This percentage of unemployment status further proves that most of the rural dwellers solely depend on the agricultural sector for livelihoods and source of income.

The results shows that the municipality faces high unemployment rates as most of the households interviewed for this study are not employed. Therefore, the employment rate is low in KSD Municipality, as noted by King Sabata Dalindyebo annual report (2012). The high rate of unemployment has adverse effects on agricultural productivity as the majority of the households are not able to use improved agricultural techniques such as buying fertilisers and pesticides to assist in improving agricultural production.

The study results reveal that there is high unemployment rate in KSD municipality which will influence the decision to adapt to climate change and variability as most farmers are not working.

4.3.7 Access to community networks

Communication networks are a crucial way of communicating and receiving new information which will assist in improving agricultural sector. The use of community networks is one of the ways of getting informed about new information technologies practices that are involved in agriculture as well as awareness programmes about out brakes in agricultural productivity.

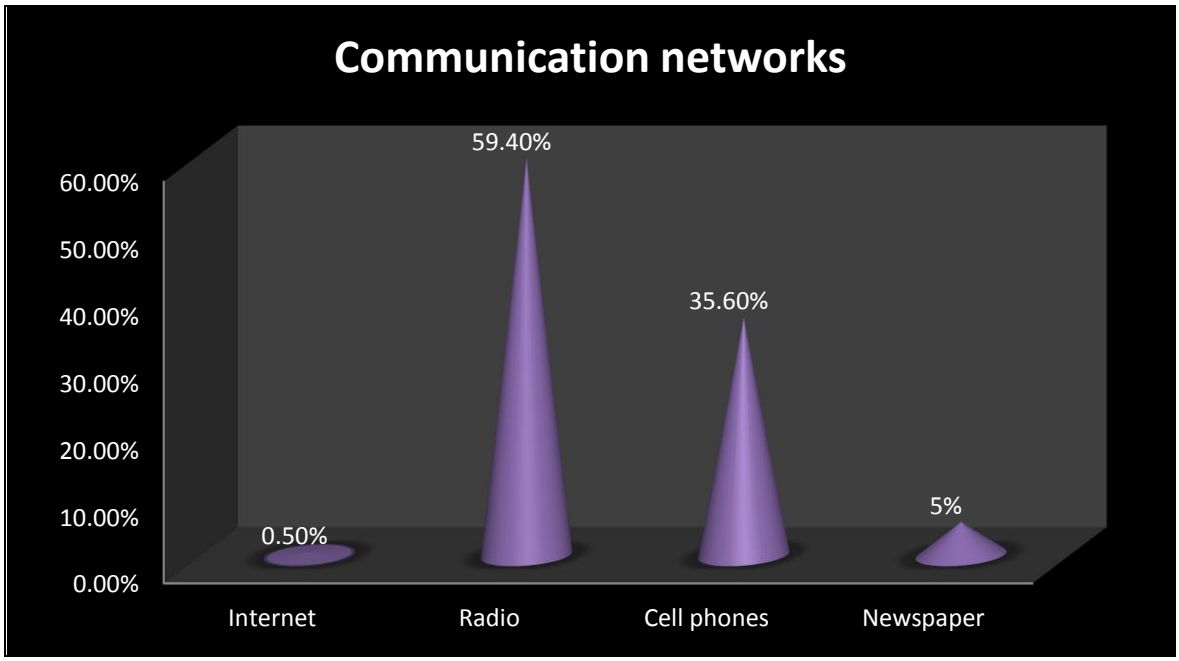

Figure 4.7: Communication networks used by respondents **Source:** Field Survey, 2014

Figure 4.7 indicates that the majority of farmers listens and receives information through radio which is their source of communication with 59.4% and is followed by cell phones with 35.60%. The least communication networks which are used by farmers are the internet with 0.50% and newspaper with 5%. These results are backed by the above presented results which indicate that there is a high level of literacy and unemployment which prevents farmers from accessing the internet and newspapers because of illiteracy. The majority of farmers also do not have finances to purchase newspapers as there are financial battles. As such, radio networks are the most commonly used communication network used due to its easily accessibility and use compared to other networks.

The use of community networks will play an important role in informing farmers about new technologies developed to improve agricultural productivity as well as informing farmers about changes in climatic conditions. The use of radios will play a vital role in delivering the climate change and variability among farmers as they have access to radios. The use of radios

as a way of communicating will increase awareness levels among farmers as they listen to radios every day. The use of radio as a communication network will play crucial role in farmers as it will increase awareness of climate change and variability which furthermore will enhance improvement in agricultural productivity in the municipality. Apart from radios, other forms of community networks which will increase farmers' awareness of climate change and variability are cell phones and newspapers as they also plays vital role in passing information as farmers' do have access to see the figure above.

The use of communication networks will play a crucial role in increasing farmers' awareness of climate change and variability among farmers. This will not only assist in increasing farmers' awareness only but further increasing communication networks such as development of new technologies, improve techniques of farming, outbreak of diseases and treatment, news on climate change and variability. All will be improved through the use of such communication channels. Thus further, improves agricultural productivity in the municipality. Furthermore, the communication networks will increase rate of adaptation measures by farmers through the communication networks which provide the farmers with strategies to employ to cope with climate change and variability and it increases decision to adapt to climate change.

4.3.8 Level of income

Figure 4.8 below depicts level of income that respondents have. Level of income is divided between R0-500 up to greater than R2000.

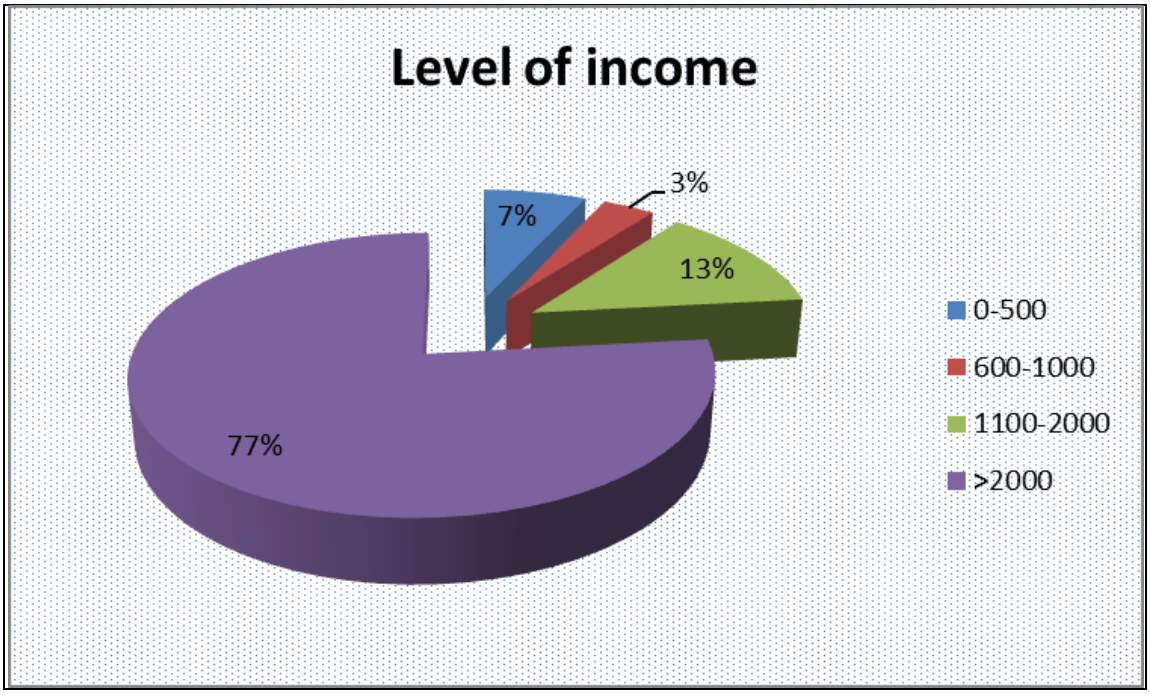

Figure 2: level of income of respondents **Source:** Field Survey, 2014.

The income received by respondents clearly complements the high levels of unemployment in the study area. A total of 13 % respondents have income of around 1100-2000 Rands per month which is in line with the poverty datum line of South Africa (Mcata, 2012). At least 7 percent respondents receive as little as below 500 Rands per month which is way below the poverty datum line. The results highlight that the study area has a high rate of poverty and unemployment. More so, only 3 % earn income between 600-1000 Rands per month and 77 %t earn above 2000 Rands per month. The income status of the respondents highlights a poor standard of living in the area that is mainly vulnerable to a number of natural and social harms.

The income status of participants in the study area further reveals that most of the farmers who are actively in agricultural activities and partaking in agricultural sector are elderly people who rely on old and grant to keep farming business actively and going. These results indicate that development of farming systems in the study area is likely to improve the welfare of the people in that community.

The results suggest that households in KSD municipality are characterised by low, middle and high household incomes since they do not solely depend on social grants but also in agricultural production. The income status of participants in the study area further reveals that the income levels obtained by households will play an important role in enhancing

agricultural productivity as they solely depends on social grants for income. Access to agricultural productivity means that households can produce and sell their produce and meet food requirements on their own which improves productivity. The results show that there is a great dependence in old age pension income by rural households as it constitutes the second largest portion of the household income as they use such income as credit to purchase inputs and pay labourers to increase agricultural productivity.

The level of income earn by a farmer will play crucial role in adapting to climate change and variability on agricultural productivity. The study reveals that most of the farmers depends solely on grants, thus influences adaptation rate to climate change and variability as farmers do not afford the adaptation strategies which will assist in mitigating climate change and variability on agricultural productivity.

4.3.9 Farming experience

Table 4.1 below is indicating the experience that smallholder farmers in King Sabata Dalindyebo Municipality have in farming and practising agricultural activities. Farming experience is one of the crucial indicators in decision making in farming farm and the adoption of new technologies as well as the application of different techniques. Table 4.1 illustrates the farming experience of the farmers interviewed in the King Sabata Dalindyebo Municipality

Table 4.1: Farm experience

Farm experience	**Frequency**	**Percentage**
6-10 years	76	38.1%
11-15 years	86	42.6%
>15 years	38	19.3%
Total	200	100%

Source: Field Survey, 2014.

The results illustrate that as much as farmers are not educated and employed they have experience in farming and having experience in agriculture assists farmers in making rational decisions which will improve agricultural productivity. The study results reveal that the most experienced farmers in the municipality range in between 11-15 years of experience with 42.6% followed by 6-10 years with 38.1% and lastly >15%. The experience that farmers have is vital in decision making concerning new technology and changes in agriculture where they

know what agricultural sector entails thus making it easier to decide on new ways of production.

The study results reveal that most of the farmers in the municipality have 11-15 years of experience which assists in improving agricultural productivity as well as they know which coping strategy to employ to mitigate the effects of climate change and variability on agricultural productivity through the use of experience they have. This experience has resulted in the increase in farmers' awareness of climate change and variability as they have knowledge about changes in climatic variables taking place in the municipality. Furthermore, the experience easily helped farmers in adapting to climate change and variability through the years of farming and knowledge of agricultural techniques that they must use to cope with changes in climatic conditions.

Farming experience will have direct effect on adoption of climate change and variability on agricultural production. The study reveals that most farmers have experience, which will have positive effect in adapting to climate change and variability.

4.4 Household sources of income

Social grants (such as old age pension, child support, disability grant, foster grants and dependency grant) are playing a crucial role in improving livelihoods as well as improving food security levels among households ever since 2001 (Altman *et al*., 2009). There is too much (about 77%) reliance on social grants, especially in rural dwellers in King Sabata Dalindyebo Municipality due to the large scale of unemployment rates, poverty rates as well as the economic depression in South Africa and developing countries (Muchara, 2011). The people who are actively participating in agricultural sector are highly dependent on social grant as most of them are elderly people. Figure 4.9 below presents the various income sources for the respondents and is expressed in percentages.

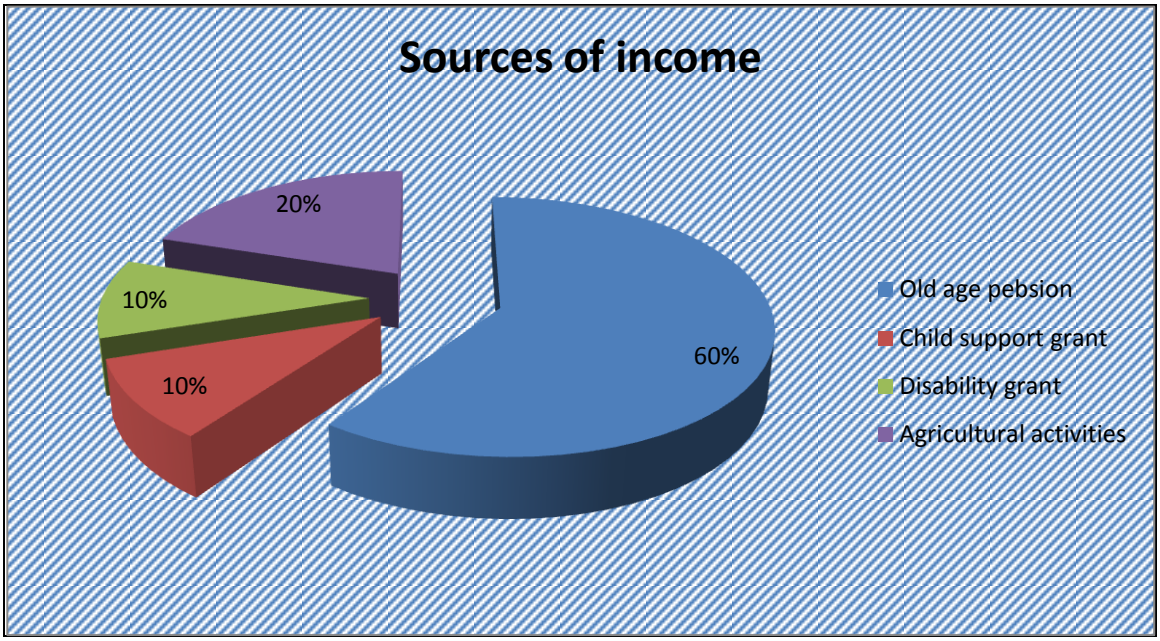

Figure 3: Sources of income of respondents **Source:** Field Survey, 2014

The results indicate that there is great dependency on social grants for income by rural households. When combined, all social grants (old age pension, child support and disability grant) constitute about 80% compared to 20% obtained from agricultural activities. The child support grant dependency constitutes about 10% while disability grants shown with 10%. This clearly indicates that the level of unemployment and lack of education plays a significant role in such a high dependency in social grants for living. This is shown with 60% of the households' group having pension as their main source of income, which they diversify into different things such as the purchase of food and other households' essentials as well as purchasing inputs for farming. According to Mcata (2012), rural households' income is hugely derived from social grants where they diversify their income in order to meet their needs as they practice agriculture to supplement their income as well as assisting in food production. The other income is generated through agricultural activities with 20% as they practice agriculture and depend on it for living and source of income. This result also proves that rural dwellers are food secured than urban dwellers due to their ability to partake in producing their own food.

The results reveal that there is a greater dependence on old age pension income by rural households as it constitutes a large portion of the sources of income. Therefore, income from various sources is used to purchase food and other households' essentials not focusing in purchasing essential things that will improve farmers' awareness of climate change and

variability such as internet, forecasting weather tools. The use of such income elsewhere, had adversely influenced the awareness of farmers' to climate change and variability as households spend much of their income in non-agricultural related essentials other than in agricultural based methods of increasing farmers' awareness of climate change and variability among farmers' in the municipality (Mcata, 2012).

The dependency of farmers to old age and child support grants will have negative influence in adapting to climate change and variability as well as taking adoption measures as most farmers are financially unstable. These results further reveal that farmers will employ less costly adaptation strategies which will have positive effect on climate change and variability for short period while it will worsen the effect on agricultural production on other side.

4.5 Agricultural Production

4.5.1 Land availability

Land is the most crucial resource and one of the scarcest resources after water (Mcata, 2012). The land availability maybe in the form of many different forms such as freehold, leased, privately owned, community ownership and communal ownership. The study has found out that land availability is in the form of community ownership where community dwellers do own the land as given by chief. People who own the land either use it for agricultural and non-agricultural purposes or sometimes rent the land out to others to use the land.

4.5.1.1 Land ownership and access to land

Land ownership implies having access to land and accessibility of land is one of the important factors in farming. According to Makhura (2001) and Mcata (2012) mentioned that South Africa is facing resource constraints because of insufficient land constitutes and this constraints it's largely faced by rural households. Land ownership can be attained through communal ownership, inheritance, buying, leasing and hiring. All of the respondents sampled in the study have access to residential land as well as arable land which assist in farming.

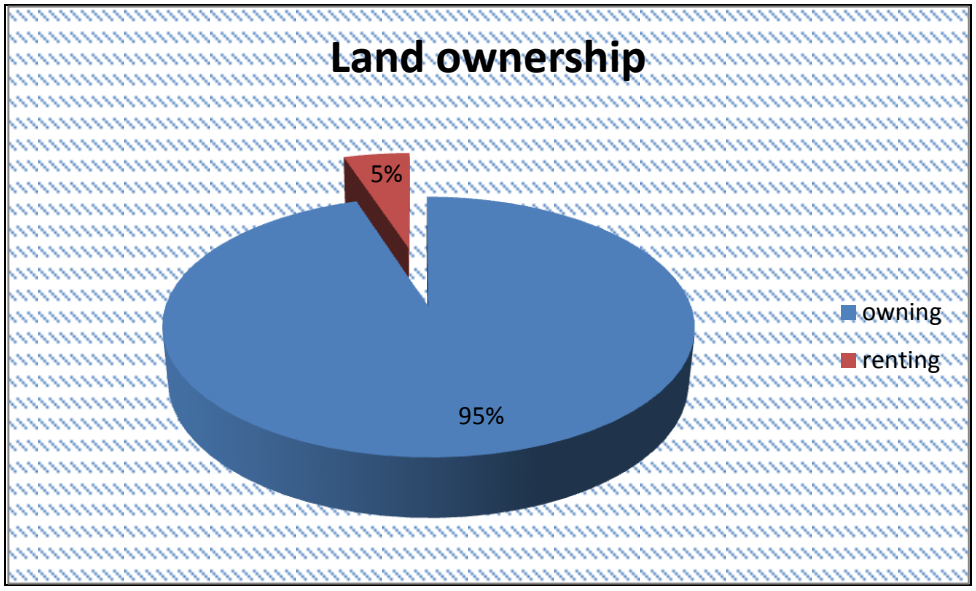

Figure 4: Land ownership **Source:** Field Survey, 2014.10.08

Figure 14.10 illustrates the land ownership by respondents. The study reveals that about 95% of the respondents own the land while about 5% are renting the land for agricultural productivity. The results reveal that the majority of the farmers own the land.

This means that those who have access to land have a better chance of producing and practicing agriculture unlike those without land. Those who were practising agriculture in demarcated rural areas but did not own the land indicated that they were renting it from those who owned land, but not utilising it. Therefore people with access to land are likely to be food secure than those without land since they can partake in the agricultural sector. Further, these people are able to generate income through production which enables them to take care of their families.

The results from the study revealed that most of the farmers in the municipality have access to land and are practising agricultural production. This means that, people with access to land are likely to improve agricultural productivity than those with no access to land. This further means that those farmers are able to generate income through production which will ultimately help in purchasing tools in forecasting weather as to improve farmers' awareness of climate change and variability as well as employing improved coping strategies to counteract the impact of climate change and variability on agricultural productivity in the municipality.

4.5.1.2 Land size

Land size plays a crucial role in agricultural productivity. Smallholder farmers in the Eastern Cape Province have land of about 0.5 ha to 4 ha producing food for household consumption and little is for selling (Sibanda, 2012). Figure 4.11 below illustrates land sizes that farmers' in KSD Municipality had access on.

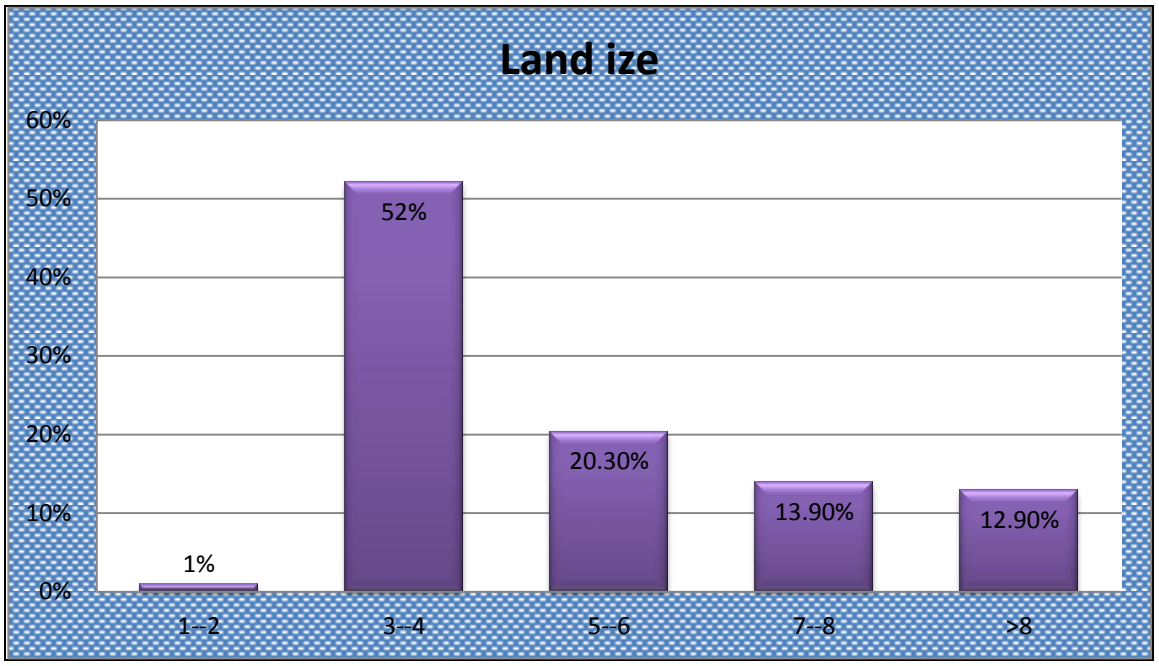

Figure 5: Land size **Source:** Field Survey, 2014

The majority of farmers in the municipality are owning land sizes of 3-4 ha with 52%, followed by 5-6 ha which is 20.3% and followed by farmers with 7-8 ha and > 8 ha with 13.9% and 12.9% respectively while 1-2 ha was the least with 1%. The majority of farmers in the municipality own 3-4 ha which is the largest portion of land owned by farmers. These results indicate that generally, farmers in the municipality had access to arable land. These results reveal that farmers owning land have greater access to more land as compared to other farmers. In having access to land, it is likely that households and farmers will partake in agriculture, where Najafi (2003) noted and stated that the greater the land owned the higher the level of production and the more food secure the household is.

Access to a large portion of land increases agricultural production for farmers which in turn increases agricultural products to be sold. The rise in production as a result of owning a large portion of land, increases income returns from sold produce which will help in employing

developed and costly mitigation measures to cope with climate change and variability among agricultural productivity in the municipality.

4.5.1.3 Soil types

Soil type is very crucial in agricultural productivity as it assists in determining the soil quality for productivity. Figure 4.12 is summarising the sampled type of soil used by farmers in practicing agriculture.

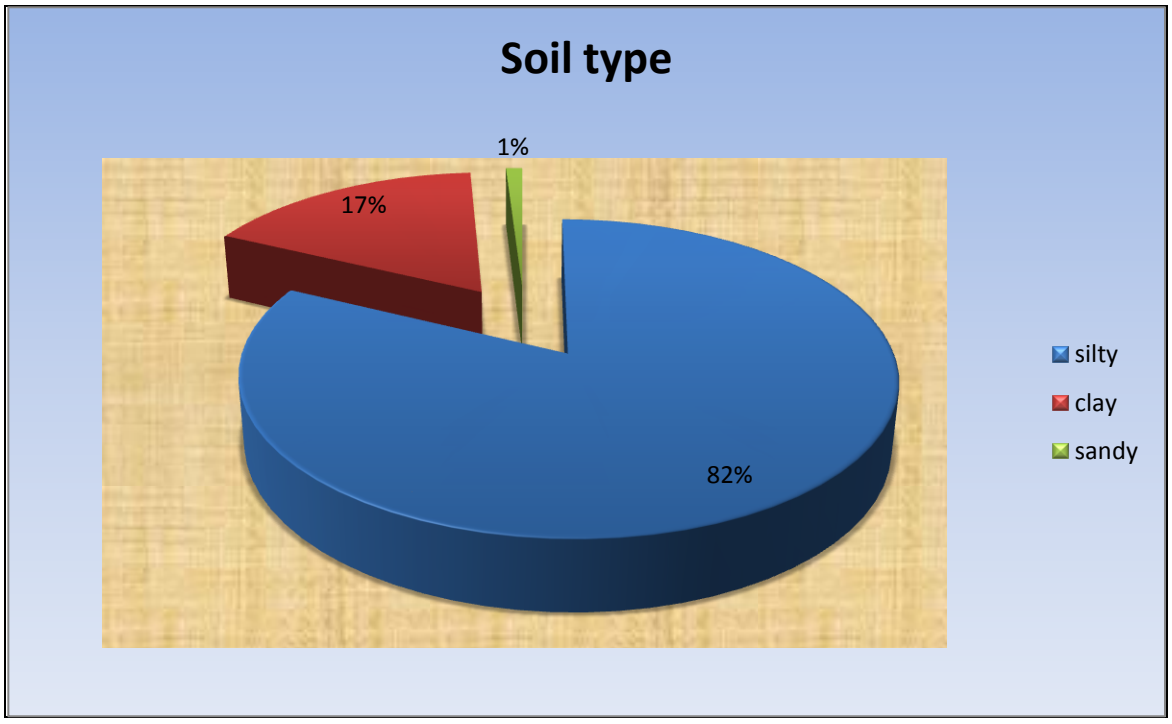

Figure 4.12: Soil types **Source:** Field Survey, 2014

The results reveal that the KSD Municipality is dominated by silty soils which constitutes about 83% while the clay soil is about 16.8% and lastly sandy soil 1%. These results reveal that this dominant silty soil is widely found in the region, and is also fertile as there is plenty of high yield farmers in KSD.

The types of soils are crucial in improving agricultural production so as to increase farm revenue, so that the farmers can be able to diversify their income levels in coping with climate change and variability as well as using such income in improving farmers' awareness of climate change and variability. Soil types play a crucial role in determining farm income.

Soil type will have an influence in climate change and variability on agricultural productivity. The soil types were found to have a positive and negative relationship and influence on

adapting to climate change and variability. As different soils responds differently to climate change and variability which influences the decision making of coping strategies to employ into such soil types.

4.5.1.4 Types of farming

The types of farming were grouped into three groups where each farmer belongs to only one group. These groups were Crop/Vegetable farming, Livestock farming and Mixed farming. The results are illustrated in figure 4.13 below.

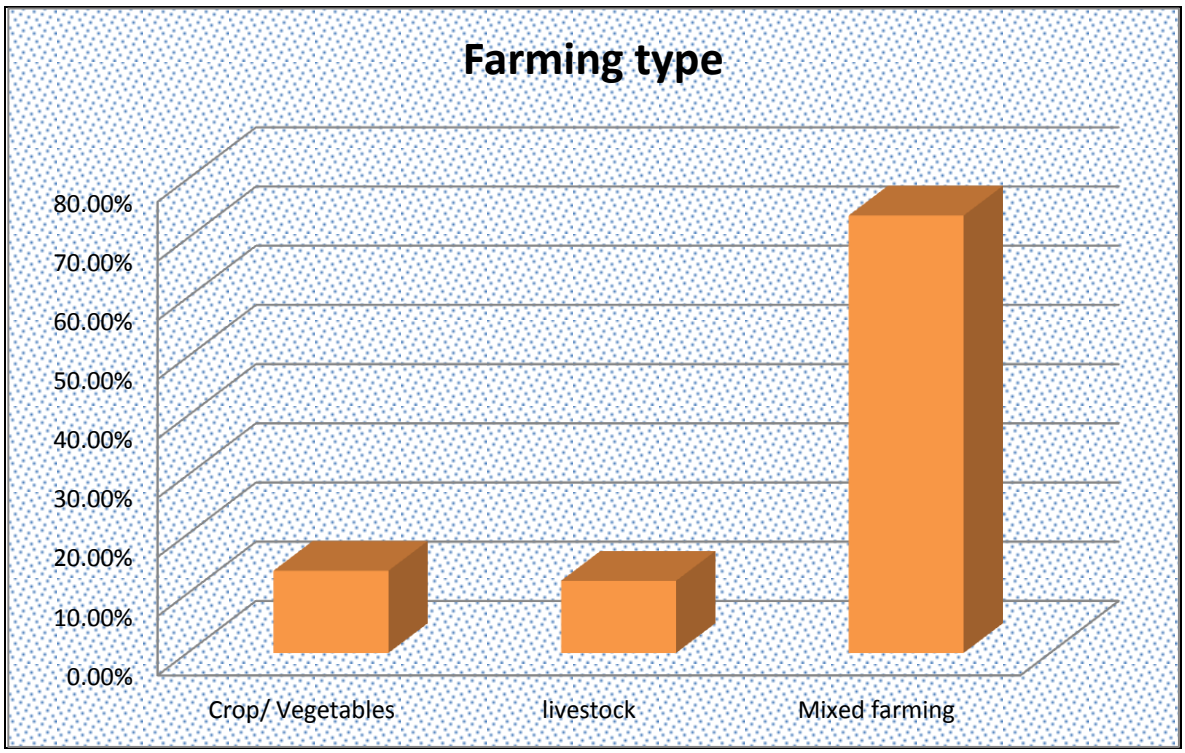

Figure 4.13: Farming type practiced by respondents **Source:** Field Survey, 2014

A total of 73.90% of the respondents were practising mixed farming, 13.90% crop farming and 12.20% were into animal farming. Furthermore, the most common types of livestock being kept by small-scale farmers in the municipality included cattle, goats, sheep and chicken. On the other hand, crop farming mainly involved the production of crops, vegetables (maize, beans, potatoes, cabbage, spinach, potatoes, tomatoes, onion and beetroot).

4.5.1.5 Farm Records

Record keeping is very crucial in farming and farm records do assists in planning and decision making of the farm. It is also important for referral purposes to check for the spending spree and inventories of the farm. Figure 4.14 below illustrates farm records.

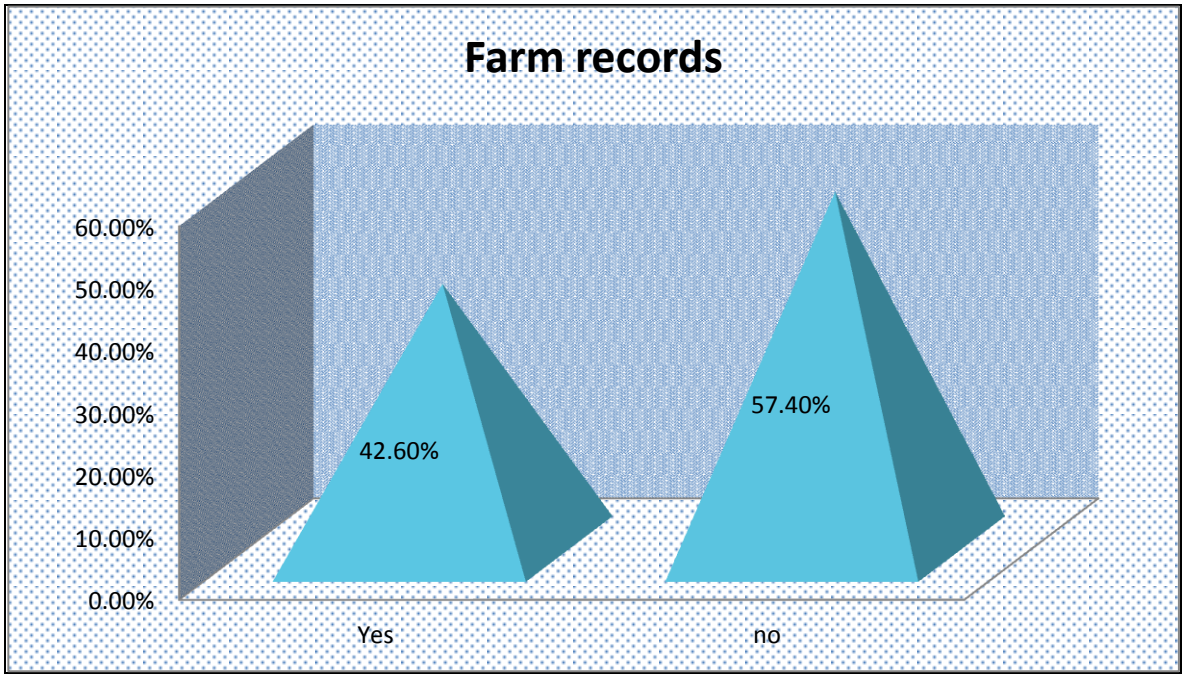

Figure 4.14: Farm records **Source:** Field Survey, 2014

The study reveals that 57.40% of the farmers do not keep farm records for their farms while only 42.60% of the farmers keep records. These results agree with the explained results of KSD Municipality which reveals that most of the farmers are lacking literacy which makes it understandable as to why most farmers do not keep records as they do not know how to keep records.

The study reveals that most farmers do not keep farm records which will influence the adoption rate of adaptation measures as there are not past records suggesting loss of yields as results of climate change and variability as compared when farmers do keep farm records. This will worsen the adverse effect of climate change and variability on agriculture as there are no records being kept to assist in decision making about climate change and variability.

4.5.2 Crop farming

This section of crop farming will be focusing on crops and vegetable growth by farmers' in King Sabata Dalindyebo Local Municipality in the Eastern Cape, South Africa.

4.5.2.1 Crops grown

The study reveals that most of the small-scale farmers are involved in crop production which is more preferred to livestock production. This means most famers are vulnerable to changes in climate because crop production is more susceptible to changes in climate than to livestock production. To overcome the risks of climate change, farmers tend to diversify their income

generating livelihood or activities. Table 4.2 below illustrates different types of crops grown by smallholder farmers in the KSD Municipality.

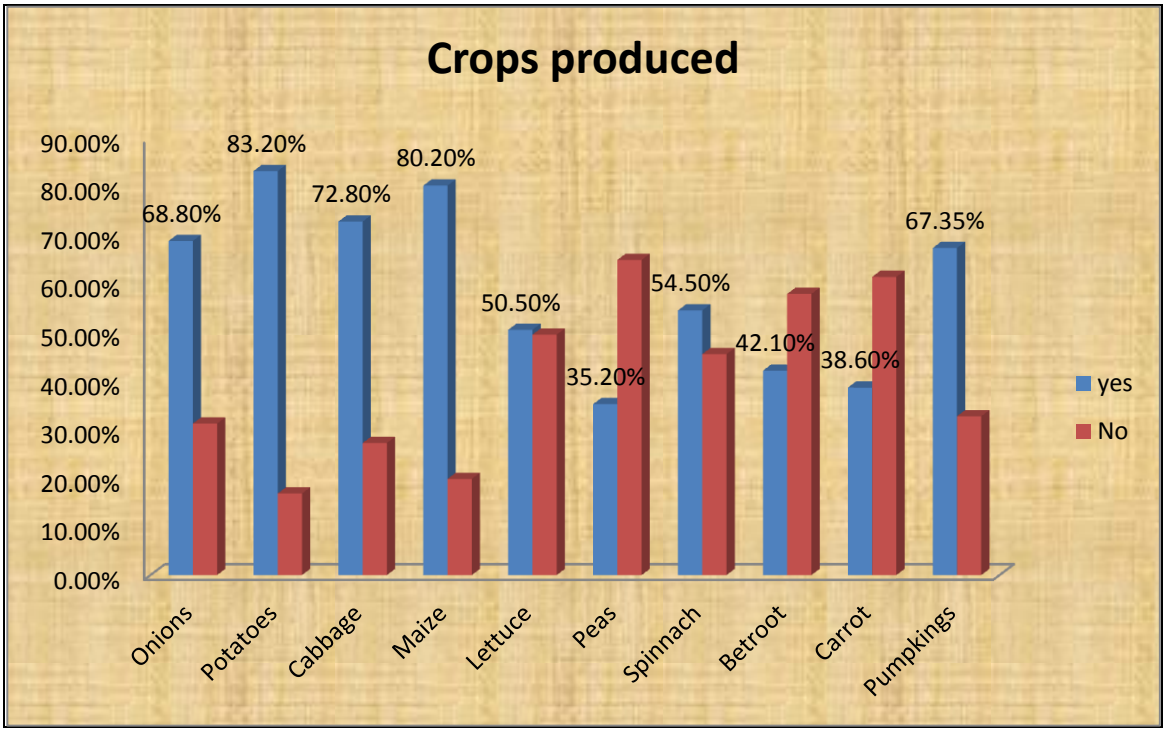

Figure 4.15: Crops grown by respondents **Source:** Field Survey, 2014.

Mcata (2012) pointed out that one of the characteristics of food insecurity in rural areas is the lack of a variety of food. Monde (2003) revealed that the lack of irrigation water prevents households from considering planting various crops and vegetables. The Yes represents farmers who grow crops and No farmers who do not grow crops. The results presented in Figure 4.15 indicate that the majority of food crops grown are staple food such as maize and potatoes with 80.25% and 83.2% respectively. The other crops grown are vegetables which are normally used as relish in these areas. The crops that are grown by rural farm owners are: onions, potatoes, maize, cabbage, spinach, carrot, tomatoes, and pepper. Among the crops mentioned, onions, potatoes and cabbage are more dominant than the other crops produced by farmers. These crops and vegetables help reduce household food insecurity since these households have daily access to freshly produced crops and vegetables.

4.5.2.2 Uses of grown crops

The crops produced by the farmers are playing a crucial role in assisting households with food as well as income. Matshe (2009) argued that the produced from grown food will assist the hunger problems which is overwhelming through practising agricultural activities. This

part only puts focus only on households who are actively partaking in farming sector. The results are shown in figure4.16 below.

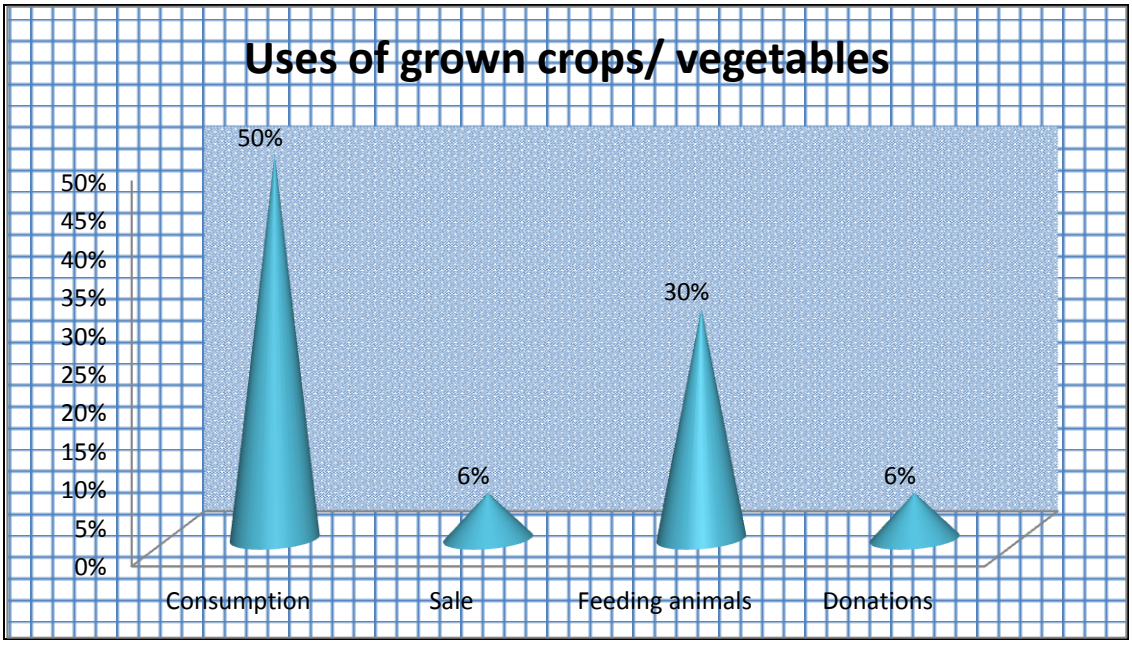

Figure 4.16: Uses of grown crops by respondents **Source:** Field Survey, 2014

Figure 4.16 presents the different ways that farmers make use of the grown crops and vegetables that they own. The following are reasons for households and farmers who practices agriculture: own consumption, selling, feed animals and donation purposes. From the results, it is revealed that farmers practising agriculture in rural areas of KSD municipality constitutes of 50% for own consumption in the household. About 6% of the farmers sold their produce to generate some household income while some 6% of the produce from farming was donated to relatives and friends. The results further state that about 30% of the produce is used to feed animals. These results shows that even though people know the importance of livestock, where there exists competition between the uses of crops, farmers tend to prioritize feeding their families first before they think of feeding animals.

4.5.2.3 Irrigate crops

According to Muchara (2011) most agricultural land in the former Transkei had been underutilisation for crops and vegetables and livestock which have great potential of expanding. Availability does not only allow to be used for livestock farming only but also used for irrigation purposes as some of crops and vegetables do not rely on rain fed rainfall for water availability instead requires irrigation.

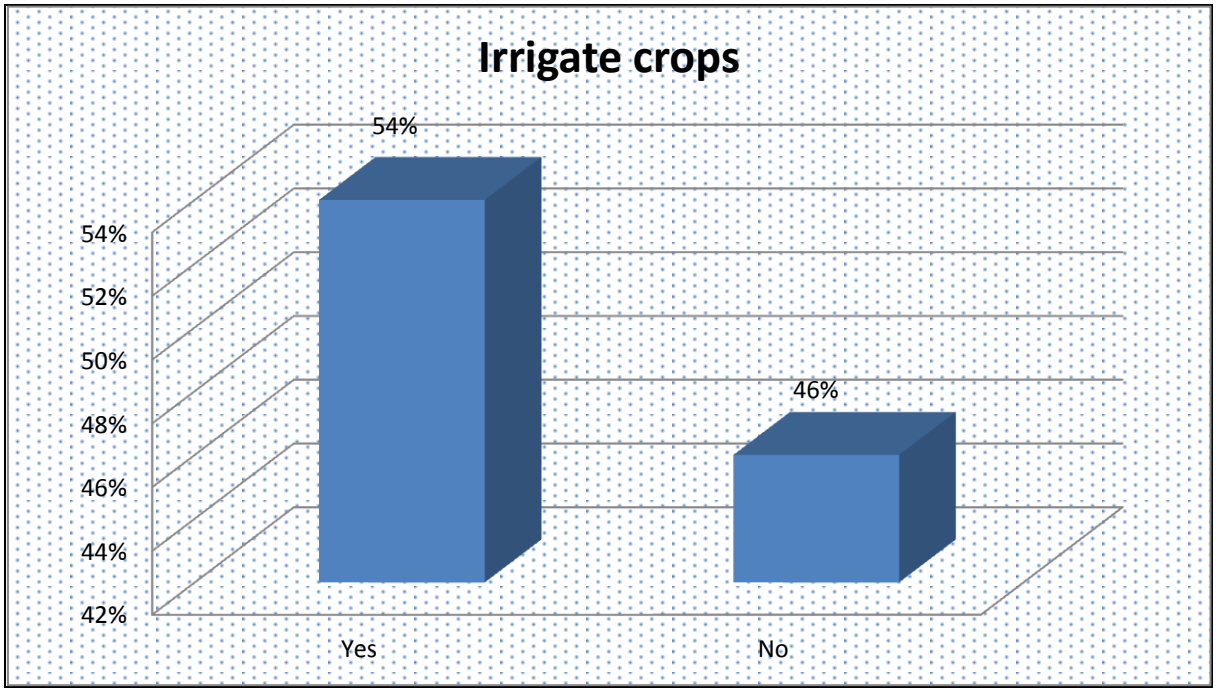

Figure 4.17: Irrigate crops **Source:** Field Survey, 2014

Figure 4.17 above is a figure which illustrates whether smallholder farmers sampled in the study do irrigate their crops or not. The diagram above illustrates that above 54% of the farmers are irrigating their crops and do not rely on rain fed water for irrigation purposes of their crops. The 45% of farmers in the sample do not irrigate their crops and are relying on rain fed water. The reason these farmers do not irrigate their water is the shortage of water as well as drought which have been dominating through the municipality resulted in leaching of dams, making difficult to apply irrigation measures.

The 54% of farmers who are irrigating their crops are not that disadvantageous as those farmers who do not irrigate as they have boreholes and artificial dams which are assisting in their irrigation processes of crops. The results shows that irrigating farmers have an advantage when it comes to climate change and variability than rain-fed farmers, because they will use those artificial boreholes and dams to irrigate crops during droughty season as result of climate change and variability compared to rain-fed farmers who will be adversely affected by drought resistance. Agricultural production from rain-fed farmers will be affected and result in a decline in productivity while irrigating farmers will not bear much effect as the use of irrigation will improve their agricultural productivity and will further use irrigation as a coping strategy to cope with climate change and variability. This is a strategy which will mitigate climate change and variability on agricultural productivity.

4.5.3 Livestock farming

This section will be focusing on livestock used by farmers in KSD Municipality for farming.

4.5.3.1 Livestock kept

Livestock are the most important species not only for meat production but also for rituals, transportation, drought power as well as fetching water and used for ploughing. There is limited number of livestock owned by farmers in KSD communities. Livestock is a store of wealth that can be easily liquidated into cash at approved prices to finance household needs and emergencies. Even though there are such constraints, there is diversification of livestock by farmers as they own more than one type of livestock species. Figure 4.18 below illustrates livestock that are being kept by farmers, where Yes denotes farmers who kept livestock and No denotes farmers who do not kept livestock at all.

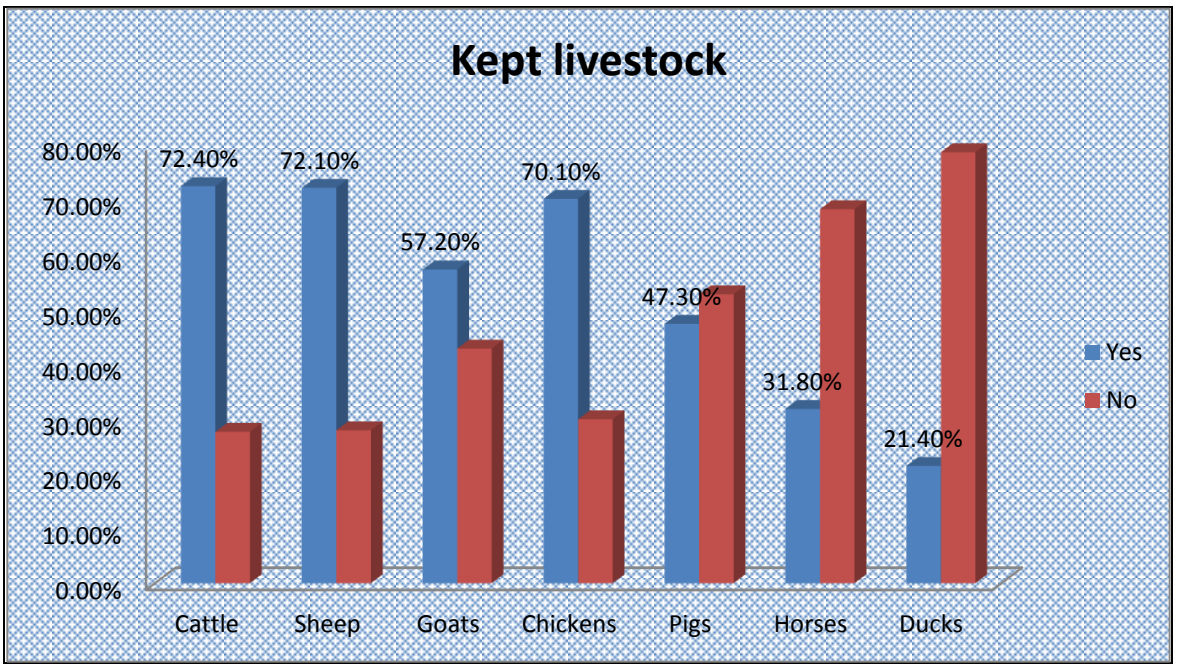

Figure 4.18: Livestock kept by respondents **Source:** Field Survey, 2014

The results reveal that cattle, sheep and chickens are the most livestock species that are being kept by farmers with cattle constituting 72.4%, sheep with 72.1% and lastly chickens with 70%. The donkeys and horses were less important and were kept for draught power and transportation uses with 21.4% and 31.8% respectively. There were few pigs kept with 47.3% of farmers keeping pigs due to the fact that there was a year when pigs were killed as result of swine fever which resulted in most of the farmers destroying pigs. The goats are following in

the footsteps of the big three livestock with 57.2% and this because they are kept solely for ritual purposes.

4.5.3.2 Uses of livestock

Livestock are the most important species in the KSD municipality because livestock are widely used for cultural ceremonies, *lobola* and exchange for money throughout the municipality. According to Musemwa (2008), the vegetation and climate conditions in the Eastern Cape make it conducive for cattle, sheep and goat production to take place. Livestock species are playing a crucial and diverse role in people's lives as most of the times livestock species are used for rituals, drought power and for consumption purposes.

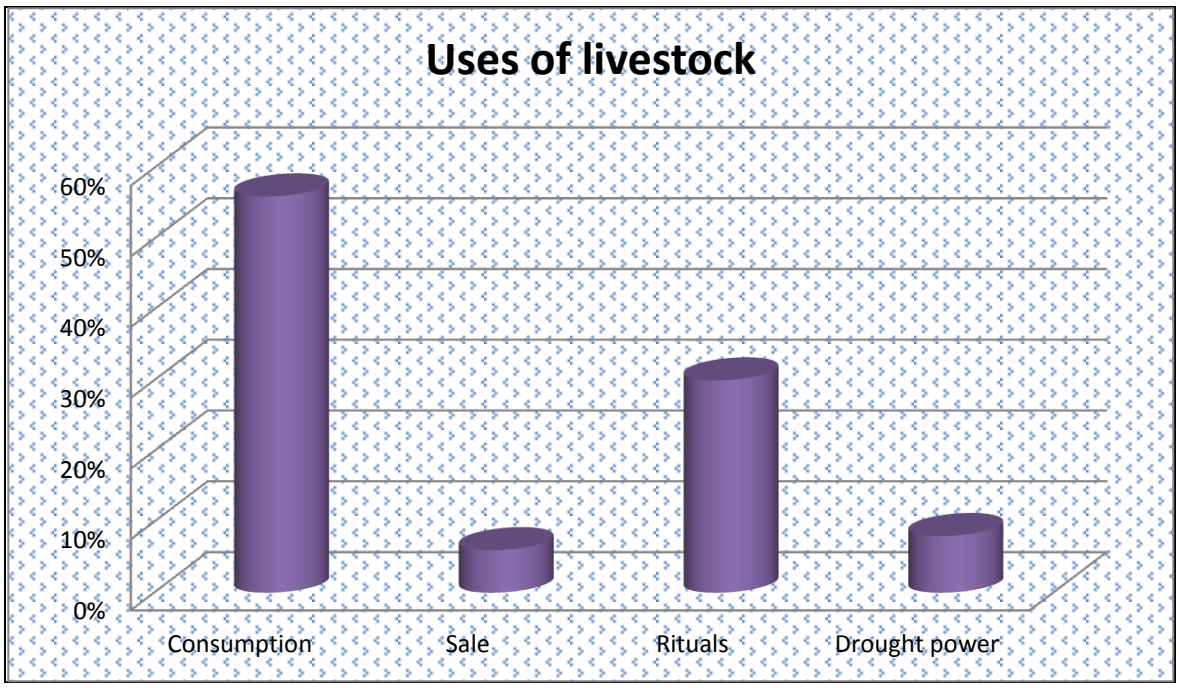

Figure 4.19: Uses of livestock kept by respondents **Source:** Field Survey, 2014

Figure 4.19 above shows the different ways that farmers make use of the livestock species they own. The following are reasons for households and farmers to practise agriculture: own consumption, selling, feed animals and donation purposes. Most of the farmers and households owning livestock were mainly used for home consumption (56%). This is because animals are drawn for rituals and draught power which is better than hand digging using hoes and it is less expensive than making use of tractors which are too expensive to use and hire although they do the job quicker and easier.

They are mostly used for rituals purposes which are 30% and as they assist and help in ceremonies such as *lobola* negotiations, cleansing ceremonies which most of the farmers value a lot. They are used for draught power which is about 8% while less is sold at 6%. They are consumed for transportation, threshing and weeding. Animals are used to transport goods, people and more often, crops to the markets. They are also important and used for household chores, such as fetching water, gathering wood and collecting thatch for roofing.

4.6. Market information, access to credit, extension services and farmer organization.

4.6.1 Market access and information

The availability of market information is very crucial for farmers because it allows farmers to make informed and rational decisions upon available information. This availability of information is important as it allows farmers which are market informed and orientated the chance to participate in marketing. The farmers who are not market orientated and well informed are not taking part in any marketing as well as those farmers who do not obtain market information in time as it will be useless by the time they receive such information. Figure 4.20 demonstrates whether farmers have access to markets or not.

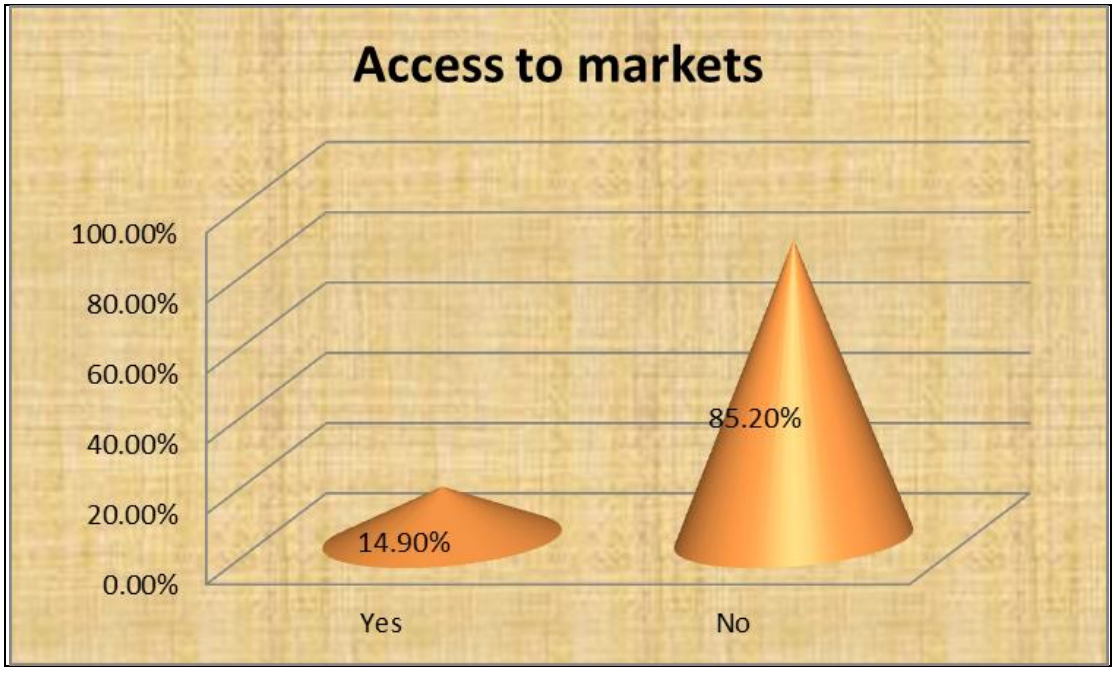

Figure 4.20: Access to markets **Source:** Field Survey, 2014

Farmers were interviewed on whether or not they had access to markets and channels for their produce. A large number of farmers, both crops/vegetables and livestock farmers, which

constitutes about 85, 2% pointed out that they did not have access to markets. Markets are less popular in both crops and livestock. This is attributed to the lack of knowledge when it comes to the marketing of the produce and market related information to the farmers. This is also the case as most of the farmers pointed out that both livestock and crop farming served a number of purposes such as rituals, store of wealth, assist the households in terms of chores, and provide other products (milk, hides, skins, seeds). The 14.9% are farmers who have access to markets and their markets are locally based.

As a result of the lack of access to markets for their produce, they ended up selling all their produce locally around their communities with the rest of the produce being for home consumption. This lack of access to markets has dissatisfied and demotivated farmers. As result of selling locally, their payments are delayed as most of the local members take their produce on credit. It is concluded that most farmers in KSD municipality do not have access to market for both of their enterprises as results of lack of market information. These results are aligned with previous results stating that lack of qualified education have played its role in this lack of access to markets and market information as the farmers are illiterate and old which prevent them in going extra miles for marketing.

The access to markets will provide farmers with income in returns after selling their production which will assist farmers in adapting to climate change and variability through income earned. The income will assist farmers in employing strategies which will minimize climate change and variability effects in agricultural production.

4.6.2 Market constraints

Among the marketing problems the farmers in KSD are facing is a general lack of markets and market information. The farmers have further complained that they are facing a lack of storage as it is difficult for farmers to store their produce after harvesting and it is difficult to get to the markets as there are no markets to deal with. Below are some of the constraints faced by farmers with regards to market access:

4.6.2.1. Storage

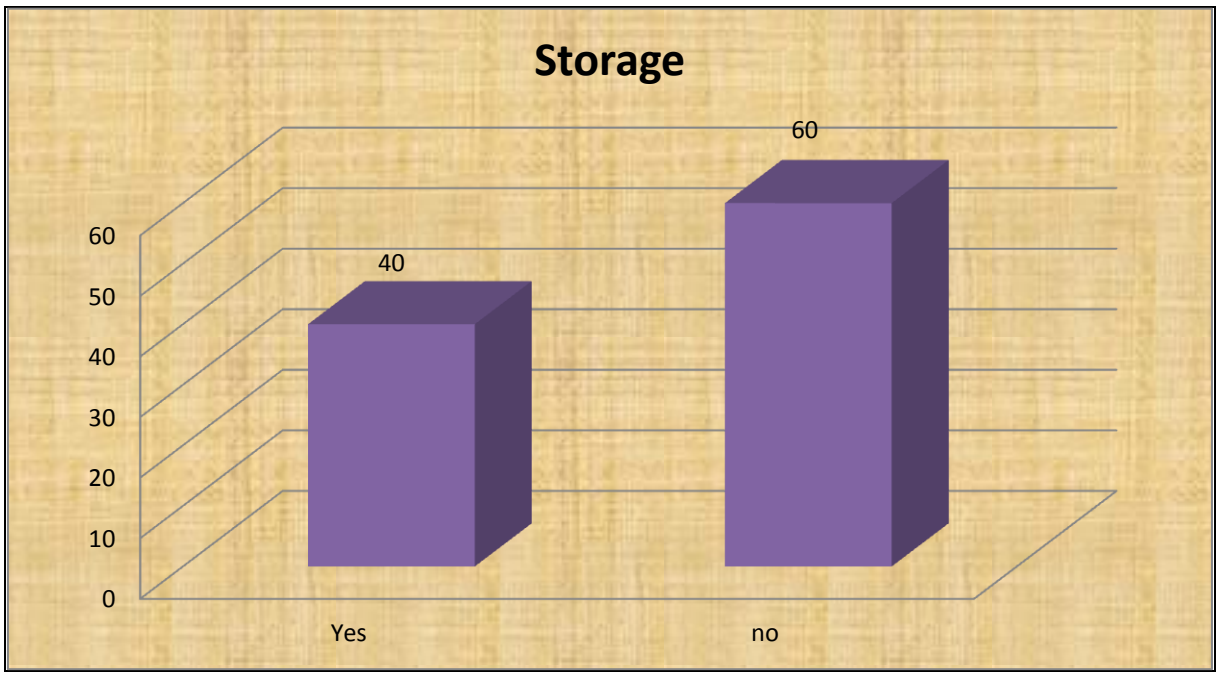

Figure 4.29: Storage facilities used by respondents **Source:** Field Survey, 2014

The Figure 4.29 above is a representation of the lack of storage facilities by farmers. The results reveal that about 60% of farmers do not have access to storage. The remaining 40% do not have storage facility as some have partial ownership although it is not up to date for storage by farmers while other farmers do hire storage facility to store their produce. The storage facility is needed and is of necessity in the farming business especially for the farmers producing crops and vegetables as they are products which are perishable and require storage immediately after they are harvested. These products require storage vicinity with high and enough ventilation and correct temperatures but the study revealed that farmers in the KSD municipality do not have storage facilities. According to Makhura (2001), this shortage or lack of storage leads to many farmers to linking up with other institutions to take their products for sale and storage.

4.6.2.2 Transport availability

Transportation is one of the most important tools in the agricultural business. Figure 4.29 below is a representation of transport availability.

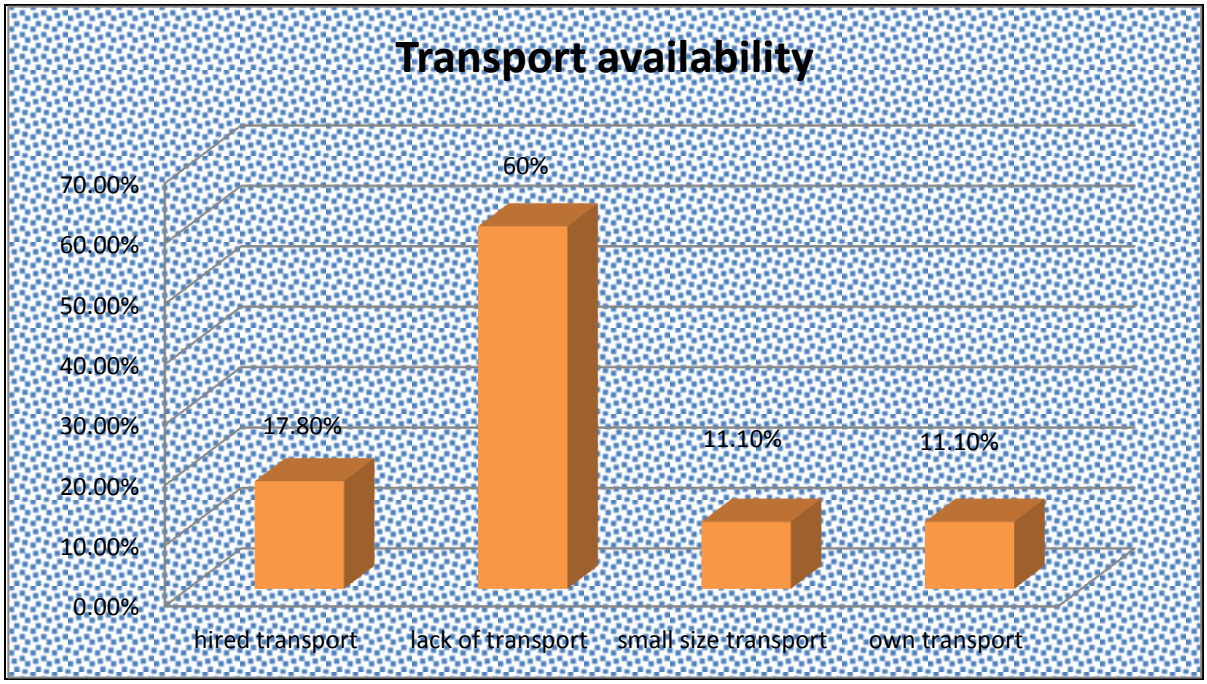

Figure 4.29: Transport availability **Source:** Field Survey, 2014

The study found that farmers have transport problems which result in them lacking market access. The results revealed that about 60% of the farmers lack transport to take their produce to the market above lack of market information. This is further nailed down by the lack of credit, so it makes it difficult for farmers to transport their produce. The study further revealed that most of the farmers hire transport for the transportation of their produce to market with 17.8%, as they lack access to income and need to higher transport to take their produce to the markets. They do not afford the transport as the transport costs are high which these farmers cannot afford. It is only 11.1% of farmers that have their own transport. This further reveals that 11.1% have small sized transport. The farmers make use of public transport as they cannot afford to hire a car or own one. These farmers are mainly former mine workers as well as people who were working in the commercial farms who have taken pension and decided to invest in farming. Transport availability is an issue that plays a role in making farmers to lack market access.

4.6.2.3 Product grading

Another important tool which is also essential for marketing is grading of farm produce. According to Maphahama (2011) the demand for safe, nutritious, high quality and healthy food has increased due to changing regulations and reasons which the sale of food must meet. Small-scale farmers do not grade their produce before selling it as they lack grading

materials. Most of the farmers do not have proper feeds to feed their animals which many markets of livestock checks before buying the livestock.

Grading of products is much needed for the quality and healthiness of the product before the buyer actually buys it. The small-scale farmers lack credit due to poverty and find product grading too expensive and time consuming. The majority of the farmers do not meet product grading requirements, leading to their produce not being allowed to have access to markets and further constraint the farmers' lack of access to markets (AGRA, 2014).

4.6.2 Access to credit

Access to credit in the farming sector is expected to play a crucial role as well as influencing the production levels in agricultural productivity as well as marketing. This availability of credit assists farmers in terms of an appropriate planning and planting because of availability of inputs, labour as well as availability of equipment which was brought with credit. It allows farmers to purchase new technology which will be used for production to increase yields as well as assists in the marketing of the produce which will ensure the sustainability of the farm.

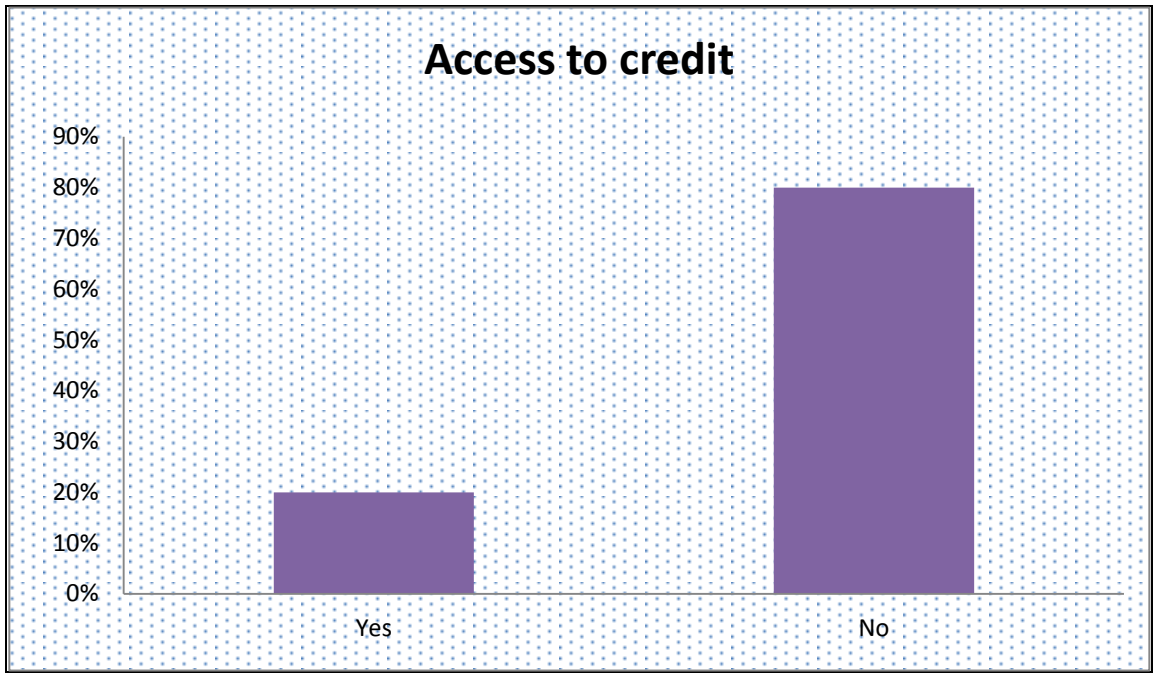

Figure 4.23 Access to credit by respondents **Source:** Field Survey, 2014

Figure 4.23 illustrates farmers with and without access to credit in the study area. The access to credit upturns the ability of a farmer with no or little reserves to acquire the essential

agricultural inputs. The majority of farmers about 80% in the study area were constrained in terms of access to credit. Only about 20% of the interviewed farmers had access to credit. The majority of farmers in KSD regions are constrained by lack of credit access which results in lack of input availability and new agricultural techniques been obtained and purchased. Sibanda (2012) noted that there is farmer organization which assists farmers where you become a member of the co-operative societies get access to credit at lower operational costs. There are input schemes strategies that the farmers who are co-operative members initiated which assist in easing farmers' problems such as agreements to sell produce as well as contracts. These results generally show that few farmers had credit in the KSD and as a result they are more likely and able to adopt improved technologies and agricultural techniques than those farmers who have no access to formal credit of any kind.

These results substantiate Pillay's (2002) observations which pointed out that the lack of credit is the main constraint that smallholder farmers are facing in developing countries, especially Africa. Owing to the lack of credit, most of the farmers do not have the capital investment to expand their productive activities which implies that there is lack of access to inputs such as seeds, fertilizers, insecticides and pesticides.

The lack of access to credit will have positive influence in climate change and variability as well as adaptation strategies. According to Mandleni (2012) having access to credit will increase the likelihood of farmers employing adaptation strategies to cope with climate change and variability and access to credit as the determinant of adopting new technologies provided to improve agricultural productivity.

4.6.3 Access to extension services

Extension services are the most vital services and play a crucial role in equipping farmers with the necessary farming knowledge, skills, communication skills and techniques in order to optimize and increase productivity (Kaliba, Verkuijl and Mwangi, 2000). Access to extension services is very important because it assists in providing education and training of farmers which on other hands helps in improving agriculture as farmers are obtaining information that will evaluate new production techniques and use of new agricultural inputs and practices. The availability of extension services have an essential role because it can influence and assist farmers' decision on farming and adaptation measures to select and use with regards to climate change and variability.

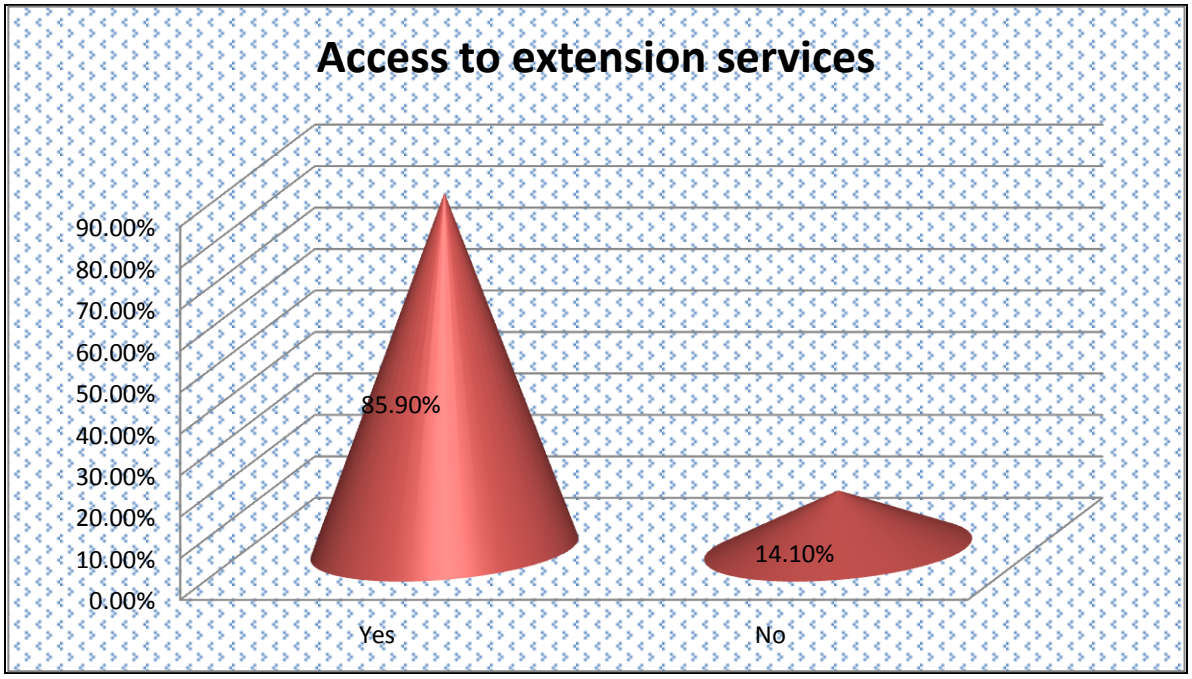

Figure 4.24: Access to extension services by respondents **Source:** Field Survey, 2014

Figure 4.24 presents access to extension services by farmers. From the results, there is access to extension services by farmers with 85.9% farmers indicating that they do have access to extension services while 14.1% do not have access to extension services of any kind. The farmers who have access to extension services, further indicated that they have access to a governmental extension officer who visits once a week and also visits once in the production period but does not visit during marketing periods. The extension officer mainly advises on crop production and other services like dipping and dosing livestock. The frequency of visits by extension officers to farmers' fields was also assessed to determine the extent to which they are in contact with extension services. Even though they have access to extension services, they do not have access to new farming practices and new technologies which is hindering agricultural productivity and these farmers are satisfied with the services they have rather than not having access at all. Farmers in KSD Municipality do not have access to climate change and variability information although they have access to extension agents. The extension agents do not inform farmers about information and forecasts on climatic conditions when they visit farmers, which increases the risk associated with the farmers' lack of awareness regarding climate change and variability.

Those farmers who do not have access at all to extension services did not have access to any visits by an extension officers which further implies that, they received no services from the government. Extension officers did not visit these farmers to teach them about the different

agricultural activities that they can practise in their farming sector. As a result, the respondents lacked skills and information related to farming. This results in a low agricultural productivity which leads to food insecurity because they cannot produce their own food due to the lack of knowledge.

The study reveals that farmers have access to extension agents and services which will have an influence in climate change and variability adaptation among farmers, since their understanding of climatic change do not depends only on their previous experience but also from extension agents. This will increase adaptation rate which will improve agricultural productivity as farmers do apply coping strategies to counteract climate change and variability effect on agricultural production. The results indicate that access to and use of extension services had a strong positive influence on adapting to climate change and variability.

4.6.4 Farmers' Organization

The Farmers' Organization is an organization made up of farmers with common problems and understanding. This is a structure which farmers join to be a member so that they can be assisted by organization members and extension agents regarding the challenges they encounter whether it is credit, access to markets, access to extension services and contract or agreement in selling their produce. The farmers' organization tries to close the gap that farmers find themselves into by providing them with other ways of solving their problems. The farmers' organization facilitates access to credit, markets and extension services at a lower transaction costs.

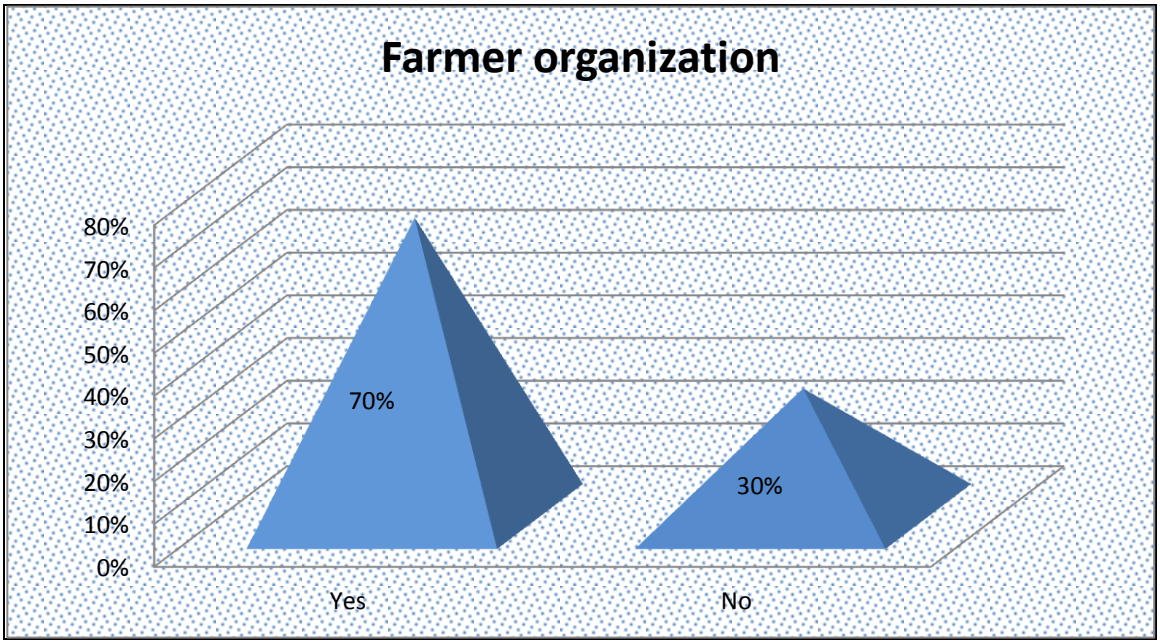

Figure 4.25: Farmer Organization **Source:** Field Survey, 2014

The Figure 4.25 illustrates the farmers' organisation of the interviewed smallholder farmers in the study area. The study reveals that about 70% of farmers in KSD are members of the farmers' organisation while only 30% of the farmers were not affiliated members of farmers' organization. The affiliated members of the farmers' organization are enjoying benefits being members by receiving general information, financial assistance, input supply services, veterinary and training services as well as transportation which all assist in farming practices. The training these farmers receive is based on new technologies and changing farming practices as well as exposure to other agricultural services. Any kind of assistance that is required by farmers are presented and achieved through this farmer organization as it groups farmers in co-operatives so that they can easily find assistance from government.

The study results revealed that there were about 70% farmers affiliated to the farmers' organisation which is capacitated to assist farmers to provide training services such as workshops training and participation as well as other arrangements which are designed to enhance and educate farmers as well as improving their level of understanding and knowledge as they are illiterate. This organization facilitates various practices which are practical and are practical techniques for educating the elderly farmers in ways of improving their production methods in such a way that it increases their yields.

The farmers' organization also assisted farmers to be aware of climate change and variability through the organization. The organization will provide farmers with climate change and

variability information as they are working closely to extension agents and also decision making about adapting climate change and variability.

4.7. Farmers awareness of climate change and variability on agricultural productivity

4.7.1 Farmers' awareness of climate change and variability

The respondents were given questions meant to record their perceptions with regards to climate change and variability in King Sabata Dalindyebo Municipality of the Eastern Cape in South Africa. Table 4.2 below is illustrating the awareness level of farmers with regard to climate change and variability.

Table 4.2: Farmers' awareness of climate change and variability

Description	Yes (percentage)	No (percentage)
Heard anything regarding climate change and variability	94%	6%
Notice changes in average temperatures	89%	11%
Notice any changes in average rainfall amount	93%	7%
Has the timing of rainfall in the seasons been shifting	86.6%	13.4%
Have incidents of extreme weather events been increasing or decreasing (drought, frost, dry spells, hails)	79.7%	20.3%

Source: Field Survey, 2014

The above results are indicating the farmers' awareness of climate change and variability in King Sabata Dalindyebo (KSD) Municipality. Table 4.2 illustrates that about 94% of interviewed respondents in the municipality agree that they have heard and also have knowledge about climate change and variability. There were only 6% of respondents in KSD

Municipality who claimed that they were not aware of anything thing with regard to climate change and variability. These results further reveal that of the majority of the farmers that have knowledge and heard about climate change and variability, about 89% of farmers had noticed changes in average temperatures while on other hand 93% of the farmers indicated that there were also changes in rainfall patterns occurring where the amount of rainfall has dropped dramatically over the years as result of changes in climate and variability. This increase in average temperatures are consistent with the findings from a study conducted by Krunger (2004) who argued that South Africa will experience increase in average temperatures over the years as some places are getting cold temperatures while others are getting hot temperatures and these farmers in the sampled areas are experiencing such changes in average temperatures.

The study results shown in the above table 4.2 also revealed what Gbetibouo (2009) and Gandure *et al.* (2012) indicated to the effect that farmers are fully aware of climate change and variability although degree of those changes have not yet clearly known. Study results also reveals that farmers are aware of climate change and variability phenomenon and also recognises the strong effect of hot temperatures and inconsistency rainfall in the country. These results are also in line with what Gbetibouo (2009) revealed in his study that about 91% of farmers in Limpopo Province of South Africa are experiencing increase in temperatures.

The results further revealed that rainfall patterns had changed and the timing of rainfall had shifted away from normal times rather towards the end of normal times it actually comes with 86.6% of farmers outlining that they had changed the operations of the farm. Farmers in King Sabata Dalindyebo Municipality has notice high rate of extreme temperatures occurring about 79.7% farmers indicating that there is increase in drought, dry spells as well as frost occurrence which have negatively influenced their agricultural productivity. These results of increase in extreme weather events are also proving what Mandleni and Amnin (2012) suggested that farmers are aware of the effect of harsh weather conditions, leading to reduction in livestock numbers as result of extreme weather events.

The study reveals that farmers in King Sabata Dalindyebo Municipality are fully aware of climate change and variability because about 94% of farmers had experience changes in climate and variability which had resulted in changes in average temperatures and rainfall. These results are also in line with the study done by Mandleni and Amnin (2012) in the

Eastern Cape Province, which indicated that about 86% of farmers' in the province are aware of climate change and variability as fully aware of changes in temperatures and precipitation due to the fact of knowing that the province is fully subjected with drought conditions. These results are similar to Kalungu, *et al*. (2013) who discovered farmers are aware of climate change and variability, hence, there are positive changes in farming practise in semi humid and sub humid regions. Furthermore, the results are also similar to Intergovernmental Panel on Climate Change IPCC (2011) conclusion that climate change and variability is a reality and most farmers are aware of the threats posed by these phenomena.

However, as much as farmers in KSD Municipality are aware of climate change and variability, farmers in the municipality are using different sources to acquire information about climate change and variability.

4.7.2 Sources of climate change and variability information

There are different sources of information that farmers use to access information on climate change and variability. Figure 4.26 below illustrates sources that smallholder farmers in KSD municipality have access to and are using to get climate change and variability information.

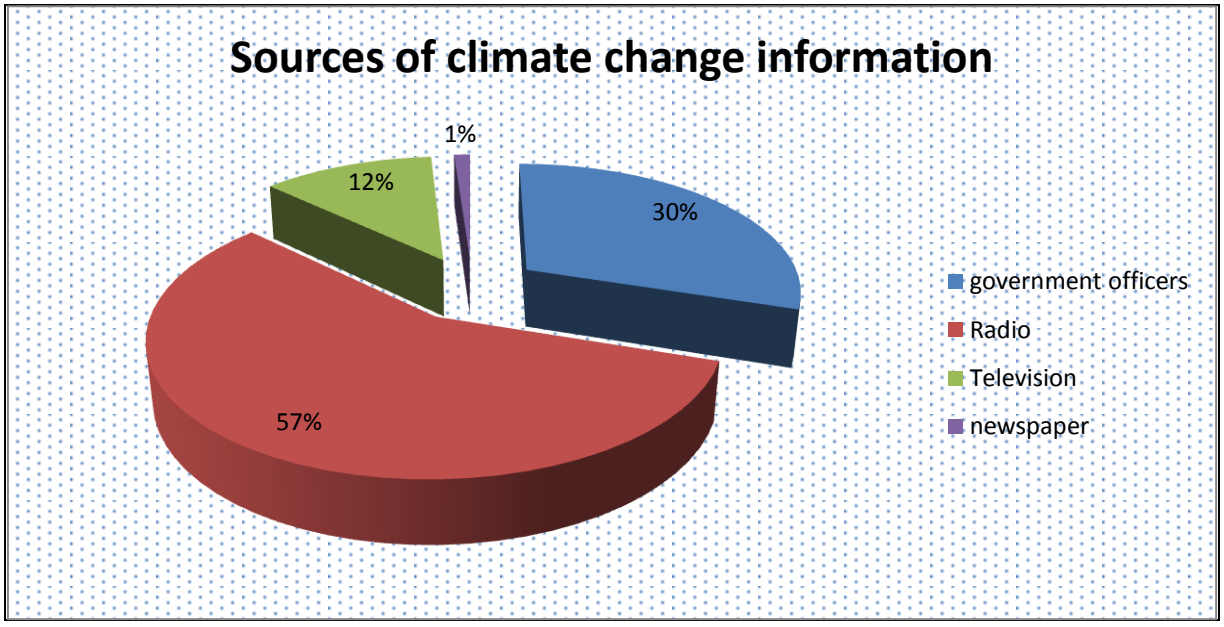

Figure 4.26: Sources of information used by farmers to receive climate change and variability information

Source: Field Survey, 2014

Figure 4.26 above is a representation of sources of information used by farmers to get climate change and variability. The results reveal that majority of the farmers receive information with regard to climate change and variability through radio with 57% while other farmers make use of government officers that is in terms of extension agents to access climate change and variability information with 30%. The use of television to acquire information by farmers is not high as radio as it is only 12% while newspaper is 1%.

The reasons for low use of newspaper and television by farmers is because most farmers are old farmers and are illiterate as they quit school at lower levels such as Grade 1. Other reason is that most of the farmers spend their time in the field which gives them no time to sit down and watch television as well as reading news papers as elderly aged people likes to spend much of their time working their fields than sitting down.

The use of radio is high in the study area and is due to the fact that they are using radio as part of communication network which makes it easier to use it as source of climate change information than television and newspaper. Most radio stations are uses their home language when they are communicating unlike newspaper and television which are using English which most of the farmers find it difficult to understand due to literacy challenges and lack of education.

4.7.3 Causes of climate change and variability

Climate change and variability is caused by two things, namely: natural activities such methane emission natural and human activities such as greenhouse gas emission, deforestation as well as burning of fossil fuels. Figure 4.27 is illustrating causes of climate change and variability on agricultural production that farmers in KSD Local Municipality thinks are the cause of such changes in climatic conditions. Farmers were asked to state what they think are the causes of climate change and variability. These causes are shown in the figure 4.27 below:

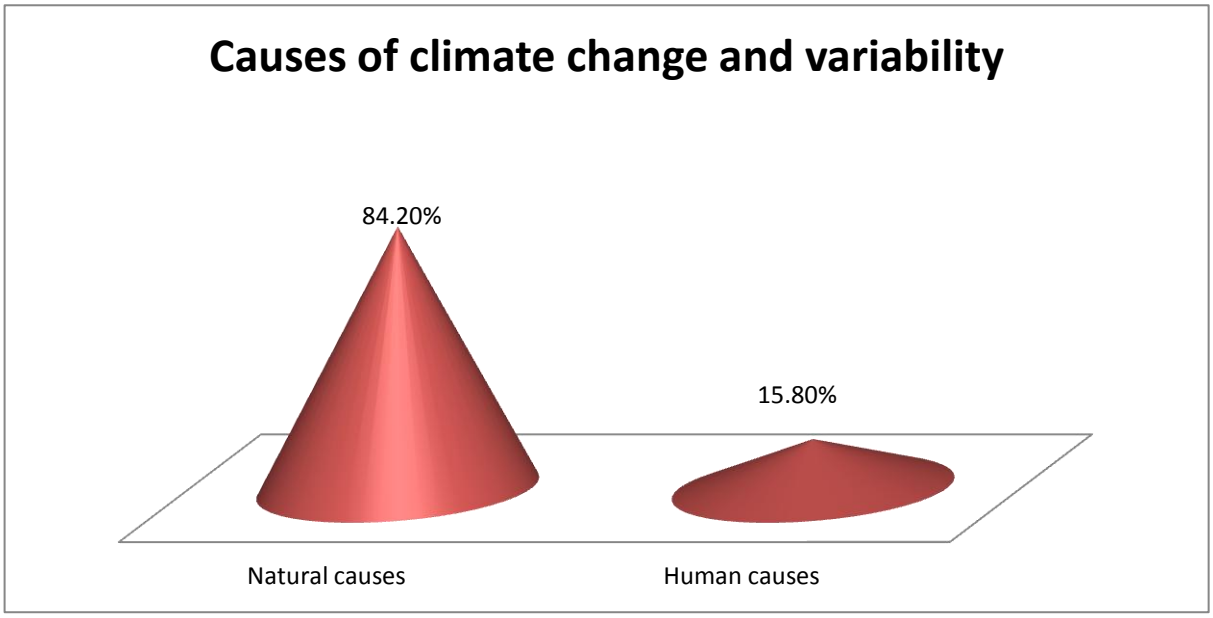

Figure 4.27: Causes of climate change and variability **Source:** Field Survey, 2014

Among the interviewed respondents, about 84.20% of farmers' believe that climate change and variability is caused by natural activities while about 15.8% of farmers' believe it is caused by human activities. Respondents who believed that climate change and variability was natural stated that climate and variability does change every time regardless of human activities and so they believed that it was an act of God. Most of the farmers (84.20%) in KSD Local Municipality are of the view that climate change and variability is a natural cause as most of respondents they believe it is a punishment from God while 15.80% think it is what was predicted in the bible while few of them believe that it is mankind as there are many veldt burning and deforestation taking place in their areas and through the country.

4.7.4 Access to training on climate change and variability

Farmer training refers to the informal capacitating by government officials either through extension agents; workshop arrangement where farmers are being educated about climate change and variability. This farmer training can be used as stepping stone which is used to meet these farmers not only rely on radios and television where they educate farmers on other various sources used by government officials to forecast climate change and understand causes of climate change as well as learning from farmers who had been farming for years and know what is best for farming. For this study, farmers from King Sabata Dalindyebo municipality had no access to any kind of training on climate change and variability. This

regards means that although farmers are aware of climate change and variability degree of knowing it further it's still difficult and as result is exposed to its effects.

As much as these farmers do not have any access to training of climate change and variability, they also face challenges in accessing climate change and variability information. Lack of access to weather events had led many farmers with no choice other than relying on local means to predict weather as well as using their indigenous knowledge to predict weather. The farmers in KSD municipality are facing challenges when it comes to access information with regard to climate change and variability which will in turn in coming years will have an effect on agricultural productivity either positive or negatively.

The lack of access to training of climate change and variability, it influences adoption measures and adapting to climate change and variability.

4.7.5. Indigenous knowledge and indicators of climate change and variability

This section is looks at the indigenous knowledge of farmers in this study area on how they use indigenous knowledge in terms of benefiting their farming practices as well as forecasting weather services and changes.

4.7.5.1 Forecasting of weather using local means and reliance on indigenous knowledge

The Table 4.3 below shows the reliance of farmers to indigenous knowledge for weather predictions as well as local means for weather prediction.

Table 4.3: Forecast of weather

Description	**Yes (Percentage)**	**No (Percentage)**
Local means of forecasting weather	45	55
Rely on Indigenous Knowledge for weather predictions	73.3	26.5

Source: Field Survey, 2014

The results have revealed that as much as farmers are aware of climate change and variability, they do not have any kind of forecasting weather services even local means as 55% of farmers indicated. There are only 45% of farmers who claim to have local means and

other means of forecasting weather events in the sampled study areas. The study further reveals that as much as farmers do not have access to climate change and variability information as well as local means to forecast weather due to such results farmers had no choice but to rely on indigenous knowledge for weather predictions with 73.3 percent of farmers relying on indigenous knowledge while only 26.7% do not rely in indigenous knowledge as they do not have any kind of forecasting means of weather. The results are indicating that as much as farmers do not have access to weather forecasting, they are making effort of using the indigenous knowledge to predict weather services.

4.7.5.2. Indigenous warning indicators for weather services

Table 4.4 below is a representation of indigenous warning indicators for weather services that farmers in the study area use to predict weather.

Table 1.4: Indigenous warning indicators

Description	Percentage
Nesting position of certain birds species	72.3
Cry frog	14.9
Abundance of insects	12.9

Source: Field Survey, 2014

The above results were the responses of the farmers on what indigenous warning indicators commonly used by farmers to predict weather events. There were five indicators which the respondents commonly used in the municipality and were given to choose from. These indigenous warning indicators were nesting position of certain bird's species, cry frog, abundance of insects, and shift of the moon position and abundance of wild fruits. The results reveal that most of the farmers are using nesting position of certain bird's species to predict weather events and this kind of indicators is usually used to predict rainfall events as when it is about to rain and will be noticed by the flock of bird's species moving around and changing their nesting positions. The other indicator was cry frog with 14.9% which also used to indicate that weather is changing and rainfall is expected to fall at any from the minute the frog cries. The abundance of insects with 12.9% is another indicator that farmers make use of to predict weather conditions as it is used for both temperatures and rainfall predictions. There are two indicators are not used by farmers in the sampled study area. The use of these indigenous warning indicators is easy to use and learn as they do not consume

any time when making use of such indicators. KSD farmers are making use of the indigenous warning indicator which is nesting position of certain species.

4.8 Farmers perceptions and Adaptation measures of climate change and variability on agricultural productivity.

This section focuses on the effects of climate change and variability on agricultural productivity as well as adaptation strategies employed by farmers to cope with climate change and variability on agricultural productivity. As much as farmers are aware of climate change and variability, there are few farmers who are changing their farming practices with regard to climate change and variability while others are not doing anything due to low knowledge and other challenges to employ adaptation measures to this phenomenon.

4.8.1 Farmers perceptions of consequence of climate change and variability on agricultural productivity

The effects of climate change and variability will differ across the regions, country as well as the world because of changes in weather conditions are not the same. This section will look at the impact of climate change and variability on crop and livestock production as well as how vulnerable the crop and livestock productivity are to these changes.

Mandleni (2012) argued that climate change and variability has long been viewed by many studies and researchers as presenting the main threats hampering the world, especially Africa in such a way that they threaten the MDG's of the United Nations (UN), especially those that are related to eliminating poverty and hunger and promoting environmental sustainability.

Table 4.5: Outcomes of climate change and variability on agricultural productivity

Description	Increasing (Percentage)	Decreasing (Percentage)
Crop Production	28,9	71,3
Diseases in crops	81,7	18,3
Wide spread of insects and pests	78,7	21,3
Livestock Production	49,5	50,5
Diseases in livestock	74,3	25,7
Mortality rate of livestock	38	62

Source: Field Survey, 2014

Table 4.5 represents results of climate change and variability effects on agricultural productivity in KSD municipality. The results have revealed that climate change and variability is affecting agricultural productivity in such a way that agricultural production is slightly declining in terms of productivity. It has been said in previous studies that climate change and variability has consequences on it whether neither positive nor negative. Farmers in the KSD Local Municipality have experienced such effects on agricultural productivity. These consequences are categorised as negative and positive respectively, where negative if farmers are suffering from these changes and positive if farmers are benefiting from such changes in climate and variability. Table 4.5 above is showing small margin of farmers who have benefiting from climate change and variability, which is 49.5% livestock and 28.9% crops. The increase in productivity will result in increase in production in areas which agricultural productivity tend not to take place. The change in climate change and variability will increase production of unproductive areas to be more productive and increases grazing pastures and soil fertility to be suitable for agricultural practices to take place. Furthermore, it is because it have increase growing period of crops to be longer than usual times and make the land so fertile as well as to have much needed nutrients for crop growth and be easily obtained by livestock species.

Table 4.5 also illustrates farmers in KSD Municipality that have experienced adverse effects of climate change and variability as agricultural productivity has declined dramatically. The study results reveal that crop productivity has decline by 71.3% while livestock production is also declined by 50.5% this as the result of changes in weather patterns. These findings of decline in crop productions agrees with Arya's (2010) findings that as a result of unreasonable rainfall, droughts and high heat there will be low crop production. This decline in agricultural productivity is as a result of extreme temperatures to the extent that many crop species would not withstand such high temperatures and they die while on livestock production lack of water availability as results of drought dominance had led to many livestock die as they lack drinking water. Due to such scenarios of changes in average temperatures and rainfall patterns, these changes have resulted in wide spread of diseases in livestock (74,3%) and wide spread of diseases (81,7%) and pests and insects (78,7%) in crop which have competed with both crops and livestock which resulted in reducing their productivity. As result of such effects of drought persistence it have led further in declining the mortality rate of livestock which is 62% and this is due to death of livestock when they are in labour as they lack feed intake and water as well as diseases.

These findings are consistent with findings of Ayanwuyi *et al*. (2010) that agricultural productivity for its level of performance is hugely reliant on a good amount of rainfall and timely as well as adequate agricultural provisions of inputs of which these farmers are lacking and there is a drop in rainfall patterns as well as shifts rainfall times which is adversely affecting productivity. These results further agree Sharma (2010) findings that there is a decrease in crop production such as food grain production and fruits quality as result of changing in rainfall patterns and soil erosion which is happening and causes removal of soil cover which have lots of nutrients. The majority of farmers have indicated the decrease is of the dominance of drought and frost which are increasing in KSD municipality and they result in high temperatures which cause leaching of water underneath with nutrients which further lead to death of crops as they lack most crucial nutrients and water intake for growth and result in weak roots which consequently result in crop death.

These results which indicate an increase in diseases and wide spread of pest and diseases in crop and livestock productivity are agreeing with Rai and Chakesang's (2010) finding's which found out a decrease in fodder yields and increase in diseases and pests as result of climate change and variability. The decline in livestock production agrees with the findings of Morton (2007) which suggests that climate change and variability effects will be felt by livestock farmers mostly in developing countries.

4.9. Responses of farmers to climate change and variability

This section is looking at farmers' reaction to climate change and variability as it has adversely affected agricultural productivity either positively or negatively. The reactions that the study is referring to are adaptation measures taken by farmers' in KSD municipality to cope with climate change and variability on agricultural productivity. According the Mandleni (2012), the main aim of having adaptation measures is to save the economies of farmers' and countries throughout the world which are adversely affected by climate change and variability and to recommend coping strategies that are suitable to deal with the adverse effects of climate change and variability. IPPC (2001) describes adaptation strategies as change into human and natural structures in response to vulnerability or projected climatic and variability effects or stimuli which will assists in moderating the harm and exploit of the beneficial opportunities.

4.9.1 Climate change and variability as a threat to farming

From the results obtained above, farmers regard climate change and variability as a threat to farming due to changes that climate and variability have changed such as changing weather events, rainfall patterns and extreme temperatures. Farmers consider climate change and variability as a threat as it has resulted in drought dominance which has led to many adverse effects in agriculture which are not suitable for farming as there is a rise in dry spells and dams as result of drought and too much evaporation due to high temperatures. This is a threat as it shifts the timing of rainfall towards the end of the season as well as increasing diseases which affects agricultural productivity negatively. Climate change and variability is seen as a threat to farming as it will result in an increase in weeds which will affect crops as they will compete for nutrients and water availability.

Farmers consider taking coping strategies to cope with climate change and variability as their produce is decreasing as a result of drought and too much heat which is affecting productivity negatively. Some farmers have changed their farming practices while the majority of farmers have not changed their farming practices.

4.9.2 Crop coping strategies

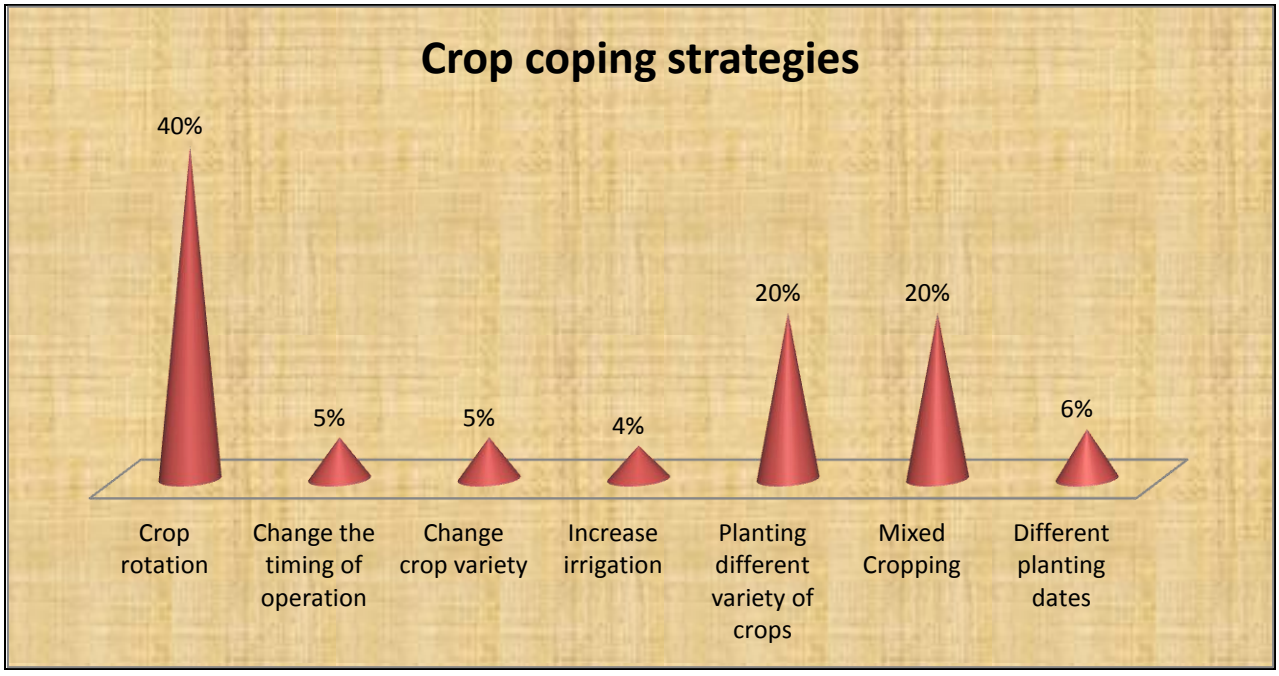

Figure 4.28: Crop coping strategies used by respondents **Source:** Field Survey, 2014

Figure 4.28 above illustrates adaptation measures adopted by crop respondents. According to Mandleni (2012) crops are not resistible to climatic conditions and not resistant either to adaptation measures which make them not to adapt better to adaptation as results of their mobility. As results of crops being easily exposed and sensitive to climate change and variability, farmers in KSD municipality have applied coping strategies to cope with climate change and variability effects on crop production. The results reveal that the most applied adaptation measure to cope with climate change and variability in crops is crop rotation with 40%, followed by planting different variety of crops and mixed cropping together with 20% respectively and the use of different planting dates with 6%. While change the timing of operation and change crop variety with 5% respectively and lastly increase irrigation with 4%. The farmers made use of such coping strategies to cope with climate change and variability because it is cheap to use them and they do not require too much knowledge.

As a result of changing climate and variability, thus has resulted in farmers applying crop rotation. About 40% of farmers have stated using crop rotation which they are now practising in order to adapt to changes in climate change and variability in the municipality. This strategy allows crops not to get used in the same environment and weather conditions as some of the crops are not exposed to extreme weather events and drought while others crops are. The results further revealed that most farmers had applied mixed cropping and planted different varieties of crops with 20% which is another strategy which is fundamental to adapting to climate change. This allows that as one crop variety is not favourable to such climatic condition, the other crop is and it grows regardless of what is happening to other crop species. The different planting dates are crucial because of the changing climatic conditions as a result of climate change and variability. It is very important to have different planting dates which will allow crops different times to germinate and grow as well as helping farmers' to have different produce which will assist in selling their produce in different times to avoid competition.

Changing the time of operation and changing crop variety which is about 5% is another strategy used by farmers. This is due to the fact that the timing of the start to rain in seasons has shifted where summer rainfall now begins at the end of November and early December while winter rainfalls begin at the end of May and early July. This allows farmers to change their cropping variety to accommodate this shift in rainfall patterns. Increase irrigation is another strategy which assists farmers as most of the farmers rely on rain fed water for irrigation. As such, by increasing irrigation farmers will increase their crop and vegetable

production as well as increasing yield. However, farmers had not used this strategy often as it competes with water which most farmers are using for livestock production and household essentials.

However, as much as farmers make use of coping strategies, there are farmers who are using a combination of coping strategies to cope with climate change. The farmers reveal that the use of combination of strategies has played a crucial role in coping with climate change. As such the combination of coping strategies has assisted in adapting to climate change and variability as well as improving agricultural productivity. The mostly used combination strategies are crop rotation, different planting dates, mixed cropping, increase in irrigation, changing the timing of operation and planting different of different varieties of crops. Farmers have revealed that the use of such a combination of strategies at first was difficult to implement as they had no knowledge of how to employ it. However, as time went on, they learned about them. The use of such combinations has played an important role in improving their yields as productivity has improved although climatic conditions are not favourable.

4.9.3 Livestock coping strategies

Livestock production is widely kept by many farmers and households as the source of wealth, ploughing, status, manure during ploughing seasons and above all livestock are the pillars of many rural households and farmers. Livestock production remains the springboard in most of the times of shocks for rural communities. Livestock production is contributing significantly to agricultural GDP as it creates employment, and vast opportunities for majority of rural people. Livestock must not be ignored as they contribute a lot to countries' economies.

Farmers are slowly responding to changes in climate and variability by employing adaptation strategies to mitigate the impact of climate change and variability on livestock production.

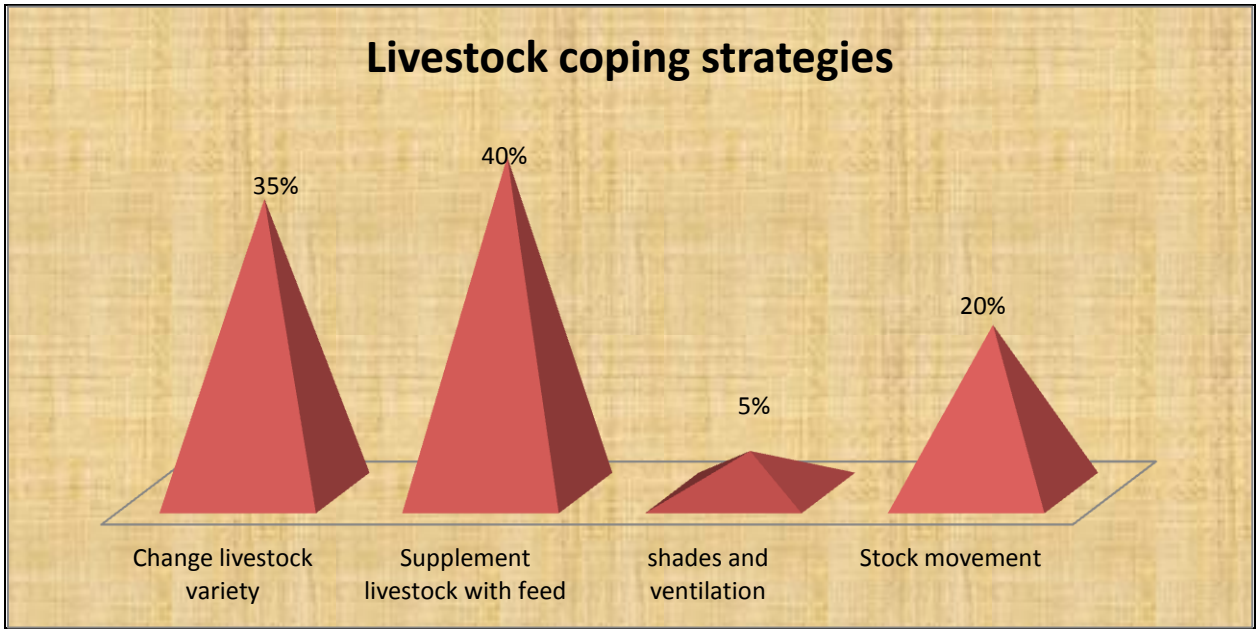

Figure 4.29: Livestock coping strategies used by respondents **Source:** Field Survey, 2014

Figure 4.29 above illustrates adaptation measures adopted by livestock farmers. According to Mandleni (2012) livestock are resistant to climatic conditions and their resistance to adaptation measures makes them to adapt easily to adaptation measures. The coping strategies that are being used in livestock production were adaptation practices that have often been used mostly by farmers long overdue without the knowledge of climate change and variability. As results of decrease in livestock production due to climate change and variability, farmers in KSD municipality have applied coping strategies to cope with climate change and variability effects on livestock production sector.

The results reveal that due to lack of literacy and finance, farmers have applied coping strategies that are less costly and do not require too much knowledge which changes livestock variety, supplement livestock with feed, stock movement and shades and ventilation. The results indicate that the widely used adaptation measure is supplementing livestock with feed which is about 40% and is an easy strategy to use. The majority of farmers are applying this strategy as most of the pastures are burnt and some pastures are sour veldts which are not good enough for livestock growth.

The results also show that changing livestock variety with 35% is another strategy used by farmers. They make use of this strategy to change livestock variety because some of the livestock variety they are using cannot withstand the harsh conditions of the province. These changes in climate change and variability had led many farmers to change their livestock

breeds to local breeds which are resistant to such harsh conditions as result of climate change and variability. These results of changing livestock variety are consistent with the observations of Musemwa *et al*. (2012) who pointed out that changing to local breeds will reduce the impact of climate change and variability on livestock as these local breeds can withstand harsh conditions as they have evolved and grown in such conditions. Such Nguni breeds easily adapt to climate change and variability as compared to exotic breeds which are constantly failing to cope with climate change and variability.

Stock movement (20%) is another strategy which is widely used by farmers throughout South Africa as well as African countries. This strategy is where the livestock are moved from plots to plots, moving livestock from drought affected pastures to greener pastures and where there are sources of water (Musemwa *et al*., 2012). This strategy is widely used by farmers who are not financially stable as they cannot afford other strategies and such results are in line and agree with Musemwa *et al*. (2012) whose findings indicate that stock movement is done by farmers who are resource poor farmers.

The study results further revealed that shades and ventilation is another strategy that farmers have used to cope with climate change and variability. This strategy is where farmers make use of trees as shades for livestock during high temperatures as they cannot afford shaded structures as they do not block radiation either. The use of trees as shading structures for animals is an outstanding natural source of shade on the pasture. The study results are consistent with the findings of Musemwa *et al.* (2012) who established that the use of simple shade as trees is reducing the livestock's radiant heat load by 30% or more. The use of shades is vital for livestock as it reduces heat stress in livestock more effectively, and reduces core body temperature and the respiration rate of beef livestock.

Farmers in KSD Municipality have also enjoyed some improvement in agricultural productivity through the use of a combination of strategies. The use of a combination of strategies by farmers has assisted farmers to adapt and cope with climate change and variability very easily as these strategies are easy to use and cheap to employ to agricultural production. Farmers made use of the above strategies in figure 5.2 as combined strategies to their fields. Combined strategies were easy to employ as farmers have already know how these strategies works, as results they are using the combined strategies interchangeable with one another. The use of coping strategies has played an important role in improving productivity although there are constraints involved in employing those coping strategies.

4.9.4. Constraints in employing adaptation measures.

Agricultural productivity is influenced by many factors which lead to more vulnerability and sensitivity. Farmers' are facing a challenge in maintaining and adapting to technology which will increase productivity and mitigate climate change and variability on agricultural sector, such challenges are knowledge and credit. Such challenges are increasing vulnerability and exposure of farmers to climate change and variability which in turn reduces their productivity. These challenges are explained through pie chart which is illustrated in the figure 4.30 below.

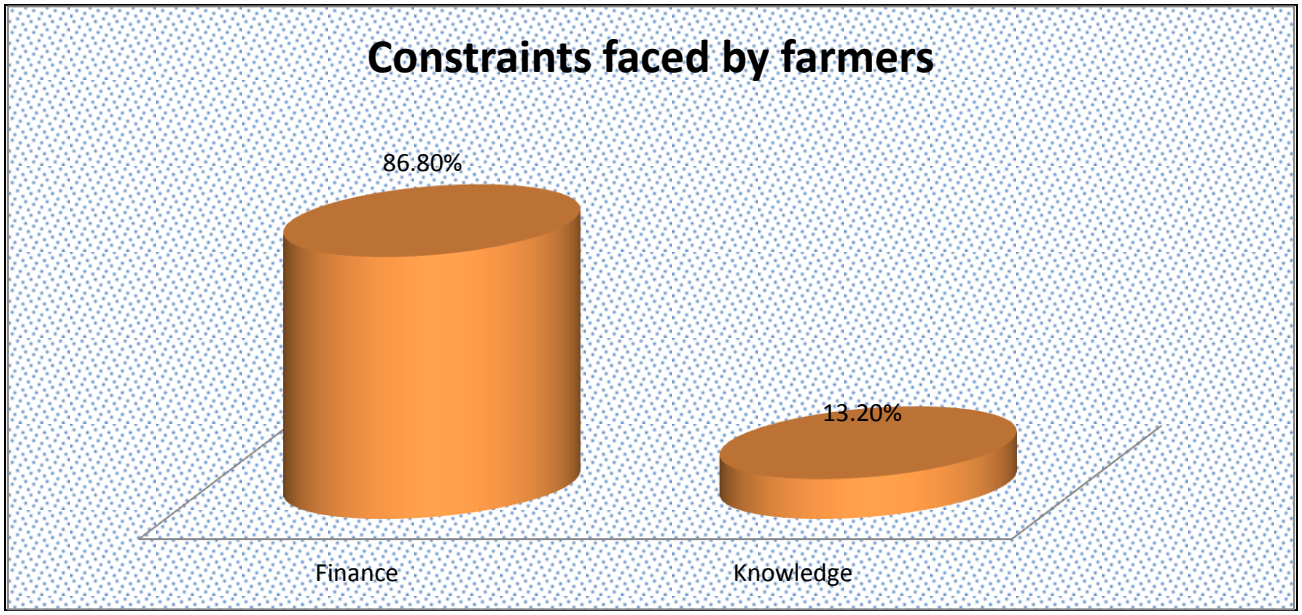

Figure 4.30: Constraints faced by farmers in employing coping strategies **Source:** Field Survey, 2014

There are a number of constraints faced by farmers in trying to adapt their agricultural activities to climate change and variability in the study area. However, the two challenges that were highlighted by a number of respondents which are influencing their adaptation to climate change and variability, which are financial and knowledge constraints.

A total of 13.2% pointed knowledge as an obstacle in their quest to adapt to climate change and variability strategies in line with agriculture, and 86.8% highlighted lack of finance as the major problem in adapting coping strategies for climate change and variability. These results revealed that there is high likelihood of a decrease in employing adaptation measures as most of the farmers are old aged which have a crucial part in making farmers' not to adapt to climate change and variability (Mandleni, 2012). This is due to the fact these elderly people

depends solely on grants for farming, which make them more financially insecure to apply coping strategies. Other reasons for financial constraints is of the result that farmers in KSD Municipality are heavily depend on social grants for income such as old age and child grant for living as well as running their farm.

Access to credit had a negative impact on climate change and variability as well as adaptation. This is due to a lack of access to credit as study results had revealed. There is lack of adaptation by farmers due to lack of finance because most of these farmers lack access to credit. The results implied that the lack of institutional support for farmers in terms of the provision of credit was an important factor in reducing the application of adaptation options by farmers in order to reduce the negative effects of climate change and variability on agricultural productivity. This result is consistent with what Kandlinkar and Risbey (2000) observed to the effect that access to credit by farmers is an important determinant of the adoption of various technologies.

Apart from finance and knowledge constraints, this study further revealed that age, gender and lack of extension officers played a crucial role in making farmers to have low rates of employing adaptation measures. Gender is playing a very important role and variable in decision making among farmers. Mandleni (2012) noted that female farmers are found to be more likely to adopt natural resource management and conservation practices than their male counterparts, but however the study results indicate that as much as females are dominant in KSD Municipality, they are constrained by knowledge as most of the farmers are literate in the municipality. The lack of access to extension officers had played a crucial role in making farmers not to apply adaptation strategies and other techniques in mitigating climate change and variability in agriculture. This is because having access to extension officers increases likelihoods of farmers' adaptation to climate change and variability as it is one of the important adaptation determinants in farm-level (Mandleni, 2012).

The results further reveals that lack of access to information and years of education had negative impacts on famers' likelihood to adapt to climate change and variability as most farmers' lack access to information have led to mixed effects on the decision-making of farmers. The lack of education by farmers' had led to many farmers to have lack of knowledge which is 13.2% and its very crucial for farming as well as in making adaptation measures which led many of farmers no to employ such adaptation measures due to lack of knowledge.

4.10 Synopsis of constraints faced by farmers from adapting to climate change and variability.

The study shows that employing mitigation strategies by farmers to climate change and variability is diluted by many factors which lead to farmers facing difficulties in employing such strategies to thwart climate change and variability on agricultural productivity. Inadequate awareness by some farmers although a majority of farmers are aware about climate change and variability as well as their nature one of the major factors the farmers are facing and it is not only farmers who lack knowledge about changes in climate and variability, it also includes the extension agents. Farmers are also compressed by lack of knowledge when it comes to climate change and variability which is escalating at a high risk as the study results indicate. These factors include the late start of summer rainfall which is important for spring ploughing and production, persistence of drought seasons which affects farmers adversely as it affects agricultural production as well as farmers' livelihoods. This lack of knowledge and awareness limit the farmers' ability to adopt and promote adaptation strategies of climate change and variability which is overwhelming agricultural productivity adversely.

Financial constraint is the second factor preventing farmers from employing coping strategies to mitigate climate change and variability. This is the cause because most of the farmers are hindered by unemployment rate which is supposed without any doubt complements and supplements agricultural incomes as well as lack of subsidies from government prevent these farmers in adopting and employing adaptive strategies.

Above those two constraints, farmers have revealed that a lack of information about climate change and variability did had an influences in their reluctance to apply coping strategies to cope with climate change and variability on agricultural productivity as most farmers faces constraints in accessing information about climate change and variability.

4.11. Summary

This chapter presented results of the study and made use of descriptive statistics. The chapter was answering objective one and three of the study using descriptive analysis where the first objective is examining the farmers' awareness of climate change and variability in KSD Municipality and the third objective is examining the coping strategies used by the farmers to cope with climate change and variability. This chapter discussed the household demographics

as well as socio-economic characteristics of the study population as well as farmers' awareness and coping strategies employed by the farmers to cope with climate change and variability. The study results show that females are the ones dominating and active in agricultural practices in KSD municipality. It further shown that there are more females working in the fields than there are men as they men are migrating to cities to look for job and better opportunities while females are working on the fields. The sections on household size on the other hand points out there are large families who are partaking in the agricultural sector, which in turn influences their production and food security levels.

Farmers in KSD municipality faces challenges in accessing markets, credit and distance to markets, storage, weather forecasting tools and access to information including the extension services. Moreover, farmers' lack knowledge on produce grades and standards and it is one area that farmers in KSD Municipality still need to acquire knowledge because the knowledge of grades and standards is the basis for farmers to enter into profitable marketing deals. The study results reveal that there is lack of access to credit which results in most of the farmers not to make use of and apply improved techniques for farming.

The study results reveal that farmers in KSD local municipality are aware of climate change and variability and have noticed that the area is getting warmer and drier with increased frequency of droughts and changes in the timing of rains. Study results reveal that farmers perceived climate change as detrimental to agricultural production as they reported various problems associated with changes in climate and variability. Farmers in KSD municipality are negatively affected by climate change and variability as their production is declining at an increasing rate. Farmers are experiencing high temperatures, decrease in rainfall and shift in time of rain in a season, extreme weather events (drought, dry spells and frost), and spread of diseases, pests and insects which all are affecting agricultural productivity negatively.

Widespread of pest and insects in crops and livestock production have coupled with widespread of disease in crops and livestock being the most reported problem by farmers. As a result of the above specified effects, farmers are suffering a high incidence of reduction in crop and livestock yield respectively. Some of the farmers mentioned that they are no longer growing crops such as cabbage and spinach because they are more prone to attacks by pests and insects whereas some totally stopped growing tuber crops because of mauls which have become active in recent years.

However, as descriptive statistics results revealed that farmers in King Sabata Dalindyebo local municipality were aware of climate change and variability effects of climate change and variability on the net farm revenue. Farmers have employed some coping strategies to cope with climate change and variability on agricultural productivity. Such coping strategies were less costly and easy to employ. Farmers were faced with constraints in adapting to climate change and variability as they were having financial difficulties in employing adaptation measures due to a lack of credit and lack of knowledge as most farmers were not educated which resulted in a lack of knowledge of adaptation strategies.

Apart from highlighted constraints, they were faced with constraints such as access to extension officers which adversely affected farmers in terms of employing adaptation measures to counteract climate change and variability on agricultural productivity. Such coping strategies to climate change and variability include increase in the use of irrigation, change livestock variety, shading and ventilation, planting different crops, changing planting dates and moving livestock.

CHAPTER FIVE

EMPIRICAL RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter empirically tests the factors affecting farmers' awareness effects of climate change and variability to agricultural productivity that is hypothesized to have the largest potential to cause adverse effects on small-scale farmers' production. It is, therefore, crucially important to determine these marginal effects of climate change and variability on agricultural productivity so as to come up with mitigation strategies to these adverse effects on agricultural productivity.

5.2 Binary Logistic Results

The model equations, as Explained in Chapter Three were used to determine the level of farmers' awareness of climate change in King Sabata Dalindyebo Municipality. The formula is briefly described by Gujarat (2003) as the cumulative logistic distribution function for factors affecting farmers' awareness level to climate change and factors influencing awareness level by farmers', as specified:

$$\log(P_i\ /(1 - P_i)\ = logP_i = \beta_0 + \beta_1 X_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (1)$$

$$P_i\ /(1 - P_i)\ = \exp(\beta_0 + \beta_1 X_1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. \ldots . (2)$$

5.3 Factors affecting farmers' awareness of climate change.

This section presents the results attained from the logistic regression model and these results focus on factors affecting farmers' awareness of climate change.

5.3.1 Diagnostic checks

In order to run the regression, diagnostic checks were done to check if multicollinearity existed in the variables. The study employed the Variance Inflation Factor (VIF) to check for multicollinearity. The greater the multicollinearity, the greater the standard errors. When high multicollinearity is present, confidence intervals for coefficients tend to be very wide and t statistics tend to be very small. Therefore, coefficients will have to be larger in order to be statistically significant, thus, it will be harder to reject the null when multicollinearity is

present. If a VIF is in excess of the strictly 4-6, or a tolerance (1/VIF) is .05 or less, there might be a problem of multicollinearity. Table 5.1 shows that all variables had a low VIF that was between 1 and 2, and the tolerance was above 0.05, and mean VIF 1.37 implying that there was zero multicollinearity. Therefore, this justified the inclusion of these variables in the binary logit model analysis (Maddala, 2000).

Table 5.1: Multicollinearity test

Variable	VIF	1/VIF
Income level	1.72	0.581098
Employment Status	1.68	0.595893
Age	1.48	0.677105
Farm experience	1.47	0.680748
Extension agents Visits	1.45	0.691444
Education	1.37	0.730682
Land Size	1.36	0.736743
Marital status	1.19	0.841279
household	1.15	0.872735
Gender	1.14	0.879352
Access to Extension agents	1.06	0.940413
Mean VIF	**1.37**	

5.3.2 Binary Logistic Model Results

The results from the binary logistic model are presented in Table 4.7 below. They indicate that the model has a good overall predictive power, as indicated by the 84% prediction. The *p-value* was strongly significant at 1% level signalling that the model was significant with likelihood x^2 of 229.36. The coefficient values explain the influence of explanatory variables on the dependent. Furthermore, the marginal effects give what would happen immediately if farmers become aware about climate change. The logistic model successfully predicted that gender, age, marital status, farming experience, occupation, land size, extension assistance, and income sources significantly affect farmers' awareness to climate change.

Table 5.2: Binary regression results on farmers' awareness of climate change and variability

Awareness	Coefficient.	Marginal effects	Z	P>z	[95% Conf.	Interval]
Gender	-2.0638	-.5159267	-1.83	0.067*	-4.272789	.1451879
Age	-2.637052	-.6592331	-2.73	0.006***	-4.529798	-.744306
Marital status	3.314897	.8286867	2.55	0.011**	.7682375	5.861557
Education	.8643915	.2160881	0.91	0.365	-1.007514	2.736297
Household size	-.0580677	-.0145163	-0.09	0.928	-1.322968	1.206833
Farm experience	2.640496	.6600942	2.61	0.009***	.655089	4.625904
Occupation	5.36276	1.340629	2.68	0.007***	1.438733	9.286787
Land Size	1.628511	.4071092	3.15	0.002***	.6156265	2.641395
Access to Extension agents and services	-5.024996	-1.256192	-2.68	0.007***	-8.699195	-1.350797
Extension agent Visit	1.248841	.312196	1.16	0.247	-.8638023	3.361484
Income level	8.218517	2.054536	3.83	0.000***	4.012715	12.42432
Constant	-16.20026	4.827652	-3.36	0.001***	-25.66229	-6.738238
Note. ***Significant at 1% level; **Significant at 5% level; *Significant at 10% level						
LR chi2(11)		=	229.36			
Prob > chi2		=	0.0000***			
Pseudo R2		=	0.8444			

Anything beyond 10% significance level was considered insignificant, while anything below ≤ 10% significance level was considered significant.

From this data results show that gender, age of the households, extension agents, marital status, education, household size, farm experience, land size and income level were variebles

that are significant. Marital status, age of the households, farm experience, extension agents, education, land size and household size were all significant at 1% and gender of the household head was the only variable significant at 10%.

Gender: the variable was statistically significant at 10% level. From results on descriptive statistics, many households from the study were headed by females (56%) than males (44%). Furthermore, regression analysis showed positive relationship between gender of the household's head and climate change and variability awareness. Therefore, females farmers are more aware of climate change and variability compared to males as shown by the marginal effects where females have a 52% probability of being aware of climate change compared to males, this is mainly because females are food producers in rural areas and spend their entire time in the farm compared to males as they migrate to cities to look for better opportunities and work. It is widely recognised that climate change does not affect people equally. Brody *et al,* (2008), noted that inequalities, economic poverty and unequal power relations leads to different impact in climate change and variability. Therefore, both genders perceive climate change differently because of the social construed gender roles which result in varying coping strategies (FA0, 2010). In Africa, women spend more time in the fields compared to men, hence, this also improves their awareness to potential threats of food security like climate change. Furthermore, women have more farming experience and information on climatic conditions and other factors such as markets and food needs of the households. Hence, this helps them in improving their level of awareness on climate change.

Age of household head: the findings were in line with the expected *priori*. The variable was strongly significant at 1 percent significant level. The coefficient was negative suggesting that climate change awareness decreases as age increases. This means that younger people are more aware of climate change compared to older people. The reason for such awareness of climate change and variability by younger farmers is because of literacy among age groups. Old age household in the municipality are illiterate as compared to young farmers. The marginally effects confirm that 65% of young people have a higher probability of being aware of climate change compared to the old. This is particularly true globally because today climate change is taught in schools and they are a number of campaigns targeting young people to be concerned about their environment.

Marital status: the variable was statistically significant at 1 percent level. The empirical results from binary model suggest that marital status has an influence in the farmers'

awareness of climate change. Married people frequently discuss about food security, therefore, they are likely to be more worried of climate changes as this threatens their yields. The marginal effect suggests that 82% of married people have a higher chance of being aware of climate change than those who are single. Past studies have drawn linkages between climate change awareness and marital status (Mandleni and Anim, 2011; Acquah, 2011).

Farm experience: The variable was strongly statistically significant at 1 percent level. This means that farmers' who are experienced have a high probability of being aware of climate change.This was proven by the marginal effect probability of 66%. The implication is that farmers with experience are 66% likely to be aware of climatic change than those who do not have any. Nhemachema and Hassan (2007) noted that highly experienced farmers are likely to be having more information and knowledge on climatic changes and livestock management. Therefore, they are likely to be aware of climate change. Moreover, the experienced farmers are usually leaders and progressive farmers in rural communities and they are usually targeted for climate change campaigns.

Land size: the logistic regression analysis indicated that a unit increase in household land size increases the chances of awareness. The variable was strongly statistically significant at 1 percent level, and the marginal effect was 40%. This means that farmers with larger land size are 40% likely to be aware of climate change than those with small land. Bryan *et al.*, (2009) found that households with large farm lands were likely to change crop varieties because of climate change awareness. Similarly, Nhemachena (2008) recorded larger farm sizes were found to encourage the use of multiple cropping especially under dry land conditions. This meant that farmers with land sized land were more aware of climate change than those without big land.

Extension service: Given an increase in access to agricultural extension services, Therefore, access to agricultural extension services were found to be strongly significantly in affecting climate change awareness. This is because farmers in KSD Municipality have access to extension services which plays a major role in improving awareness levels of climate change and variability compared to farmers with no access to extension services. As result of access to extension services, turns to play crucial role in informing farmers about climate change and variability. Luseno *et al*., (2003) found that the more the farmers have access to extension services and information about climate change, the more they are likely to be aware and adapt to climate change. Extension services play a huge role in informing farmers about climate

change. The marginal effect was 25% higher for farmers who had access to extension services than those who were not. Therefore, it means having access to extension services increased chances of being aware of climate change.

Annual income: The study found that total annual farm and non-farm income of the household has a positive and significant impact on climate change awareness by the farmers'. The variable was statistical significant at 1 percent with a marginal effect of 54%. This meant that farmers who received income were 54 percent likely to be aware of climate change than those who were not. The plausible response maybe that the higher the income in households, the greater the chances of being food secure. Therefore, increased access to food means that households are in constant touch with market players who may be able to share climate change information. Archana and Reddy (2013) noted that households that receive more income were aware of climate change because the income is reinvested to agriculture while those farmers with low income were not aware of climate change and variability as they do not reinvest their income to agriculture. This leads to farmers being able to get more information for better crop production.

5.4 The analysis of effects of climate change and variability on farm revenue

Thus far, a descriptive analysis and interpretation of the results has been given and illustrated in Chapter 4. As explained earlier on, in Chapter Three, one of the objectives of the study was to find out the effects of climate change and variability on farm revenue. This effect of climate change and variability on farm revenue was tested using the Ricardian model because it is an econometric model used to analyse the relationship between agricultural productivity and climate through regressing sets of climate variables such as temperatures and rainfall as well as other socio-economic variables with farm revenue obtained from agricultural productivity. The use of Ricardian model beta values (B_1,B_2,B_3,B_4,B_5,B_6,B_8,B_9,B_{10},……B_n) were obtained as they measure how strongly each independent variable (X_1,X_2,X_3,X_4,X_5,X_6,X_7,X_8,X_9,X_{10},….X_n) influences the dependent variable which is farm revenue (Y).

The coefficient values measure the expected change in the dependent variable for each unit change in each independent variable, while all other independent variables remained equal. According to Gujarati (1992), the sign of the coefficient depicts the direction of the influence that the independent variable will have on the dependent variable. It follows that a positive quadratic term indicates a positive relationship between the dependent variable and

independent variables as well as a U-shaped relationship between net farm revenue and the climate variable. On the other hand the negative quadratic term reflects a negative relationship between the dependent variable and independent variables as well as an inverted U-shaped relationship between net farm revenue and the climate variable (Mendelsohn & Dinar, 2003). The summary of the parameter estimates of the determinants of agricultural productivity is illustrated in the table below.

5.5 Ricardian Regression Estimates of the Farm Income Model per hectare (R/ha)

The Ricardian results were divided into two sections where the first section looked at the Ricardian analyses of climate change and variability on the net farm revenue while the second section looked at Marginal effects of climate change and variability on net farm revenue per hectare.

5.5.1 Ricardian analyses of climate change and variability on net farm revenue

Table 5.3 presents results from the Ricardian regressions. The use of the Ricardian and multiple models was employed to observe and indicate the effect of the change in temperature and rainfall, socio-economic variables and type of soils and on farm revenue (agricultural productivity) in smallholder farmers in King Sabata Dalindyebo Municipality. The results were estimated for farmers who practice agriculture in the King Sabata Dalindyebo Municipality. The results indicated the effects of socio-economic variables, soils and climatic variables on net revenue. The regression accounts to almost 90% of the climate change and variability effects on farm revenue.

Table 5.3: Ricardian results of climate change and variability on net farm revenue

INDEPENDENT VARIABLES	**Parameter estimates (ß)**	**Significance (S.E)**
Summer temperatures	-5 345.67*	-0.085
Squared summer temperature	185.57*	0.093
Winter temperatures	675.4***	0.086
Squared winter temperatures	-20.40**	-0.010
Spring temperatures	1279.68**	0.068

Squared spring temperatures	45.68**	0.046
Autumn temperatures	1665.88**	0.030
Squared autumn temperatures	6.70*	0.080
Summer rainfall	-1668.50***	-0.084
Squared summer rainfall	194.60***	0.064
Winter rainfall	-285.46	-0.073
Squared winter rainfall	5.76	0.015
Spring rainfall	267.64*	0.077
Squared spring rainfall	1.088**	0.029
Autumn rainfall	-547.70*	-0.075
Squared autumn rainfall	56.65*	0.050
Silty soil	6053.65	0.071
Clay soil	-4160.88	-0.035
Sandy	-132.45	-0.68
Farm experience	184.78	0.020
Level of education	-735.29*	-0.010
Livestock ownership	-987.56***	-0.056
Crops grown	777.67***	0.034
Household size	765.24*	0.731
Farm size	398.23	0.046
Irrigation (Yes/No)	0.034	0.04
Access to credit	-0.088*	-0.086
Access to extension services and agents	0.069*	0.0707
Distance to input and output market	0.045	-0.035
Mixed-farming crop-livestock	0.0171	0.023
Constant	86978.45*	-0.681

R-squared	0.905	
R-squared	0.785	
F	3.53*	
N	**170**	

5.5.1.1 Effect of temperatures and precipitation on net farm revenue

The regression results indicated that climate change and variability have significant effects on net revenue (agricultural productivity) in smallholder farmers in King Sabata Dalindyebo Municipality. The results from the Ricardian model revealed that farm revenue is influenced significantly by climatic conditions, soil types and lastly by household socio-economic variables. The seasonal climate variables' effects on the net revenue were inferred linear and quadratic term. Table 5.3 above illustrates that summer temperatures are negative for both dry and raining seasons while short seasons such as winter, spring and autumn with short raining seasons are positive. Differences in seasonal temperatures and precipitation affect agricultural farm revenue differently. For example, summer temperatures and precipitation have a significant impact on the farm revenue compared to other seasons of the year, as shown by negative coefficients while all other seasons' coefficients are positive. These results are consistent with Nhemechana and Hassan's findings (2008) to the effect that climate attributes (temperatures and precipitation) have a significant effect on agricultural farm revenue. The square terms reveal that doubling winter and autumn precipitation will lead to a negative impact on net farm revenue while summer precipitation will lead to an increase in the farm revenue.

The study findings were generally in line with many other studies done (Mendelson, 2006 study, Kurukulasuriya and Mendelson (2006) study in Sahel, Kurukulasuriya, 2007 study in the Eastern Cape, Sibanda, 2013 in the study in Eastern Cape) using Ricardian model to analyse the effect of climate change and variability on the net farm revenue. The study results from the regression indicates that there is a quadratic relationship between climatic conditions and net farm revenue as shown by table 5.3 above whereby the summer temperatures coefficient is negative while the squared summer temperatures' is positive. This result suggests that there is a U-shaped relationship between farm revenue and climatic variables as shown by summer temperatures, which stipulate that summer temperature has adverse effects on the net farm revenue. This adverse effect by summer temperature will have an influence between summer temperature seasons and farm revenue until a turning point is reached which

will be far away from such value and will have a positive effect on agricultural farm revenue. The study coefficients from the model of the squared values are important and play a crucial role as squared values depict curvature direction and steepness. Climatic variables and farm revenue have negative a relationship, whereas the study curvature is downward as there is a negative relationship between climatic variables and agricultural farm revenue.

These results suggest that net farm revenue decreases with additional summer temperatures and precipitation. Furthermore, study results revealed an increase in the net farm revenue in spring temperatures and additional autumn and summer. These results are in line with the findings of Seo and Mendalson (2007a) that net farm revenue increases when there is falling rainfall in summer, spring and summer seasons respectively and it is expected that such falling in rainfall will have a positive impact on the net revenue especially those areas with a high dominance in rain water for agriculture. However, even though increase in rainfall patterns in autumn and spring which are expected to improve grazing pastures quality and quantity, on other hand they will increase dominance of diseases among pastures which will reduce gains from improved pastures which play a role in increasing net farm revenue. The reason for the reduction in summer season is because of high rainfall patterns in South Africa as much rainfall is very high during this season, so the increase in rainfall resulted in too much surface runoff which results in damages crops fields and feedlots for livestock. Thus the reduction in agricultural productivity as a result of an increase in precipitation will lead to a reduction in the net farm revenue.

However, the rise in winter temperatures as shown by the study will have negative effects on the net farm revenue although this season is the period of maturation of crops and the calving period for livestock. While on other hand, the increase in temperature during the spring and autumn seasons has benefits as it increases agricultural net farm revenue respectively as there is a positive relationship. This positive relationship between net farm revenue with spring and autumn is because high temperatures which are advantageous for harvesting, as most grown crops have matured and are ready for harvesting and assist in drying crops quickly and easy to facilitate harvesting are prevalent. The increase in temperatures is beneficial for raising calves as temperatures suits calves growing time with minimum temperatures. High temperatures with low precipitation during spring and autumn will be advantageous for the harvesting time, reduce the loss of output in crops and growth of calves. Farmers are more likely to raise their productivity and net farm revenue with low temperatures and enough rainfall during summer seasons. However, during winter seasons, this increase in rainfall

results in an outbreak of diseases and pesticides which adversely affects agricultural productivity. These results are consistent with the findings of Mekonnen (2012) to the effect that the summer rise in precipitation has adverse effects on agricultural productivity and the net farm revenue.

During the spring season, an increase in precipitation shows a positive relationship with the net farm revenue. Increase in rainfall during the spring season is crucial for crops' germination as well as the growth of green nutritious grass which contains lots of nutrients for livestock, more especially calves which are already grown up. Thus an increase in rainfall as is important as it increases agricultural productivity and the net farm revenue. In the autumn season, an increase in precipitation will influence net farm revenue negatively. The reason for reduction in the autumn season is mainly due to the fact that during this season, harvesting takes place and by this time all crops have grown and are ready to be harvested. The increase in precipitation is damages crops during this season. The increase in precipitation affects farm revenue, especially revenue derived from livestock as there are severe deaths of livestock as a result of an outbreak of diseases, shortage of feeding as most of the grass is washed away by flooding and surface runoff.

This increase in rainfall reduces irrigation use as most farmers rely on irrigation for farming and ultimately reduces farm revenue, while an increase in rainfall during the spring season is crucial for crops' germination as well as growth of green nutritious grass which contains lots of nutrients for livestock, more especially calves which are already grown up. While on other hand, the increase in rainfall will be beneficial to some farmers on dry lands who rely on rain-fed water for farming which will assist in their agricultural productivity which will increase their farm revenue.

5.5.1.2 Effect of socio-economic factors on net farm revenue

The regression on Table 5.3 above, further illustrates that agricultural productivity (such as crops grown and livestock ownership) and access to extension services have a positive relationship to farm revenue. Access to extension services has a positive relationship to net farm income as it improves agricultural productivity and is significant. The access to credit, level of education, and distance to markets have a negative impact on farm income as most of the farmers lack education as farmers have an informal education while they also lack access to credit. The market distance is negative as farmers are not close to the market which forces

them to incur high costs in travelling to the market place. This is time consuming as the farmers stay far away from farm plots.

Household size was found to have a positive influence on net farm revenue. This is consistent with the descriptive statistics (4.5) which revealed that household size in the study was generally high. According to Phororo (2001) household size can be taken as proxy for labour availability. As a result, most farmers have little care about the farm as there is high need for farmers' family members who are working on a full time bases on their farm and as a result the farm revenue is affected. The impact of household size is positive with the net farm revenue as shown on beta co-efficient with 0.046. The occupation of the farm head whether main and secondary occupation and level of education by farm members have a positive correlation with the agricultural productivity (Farm income). Thus the high concentration of household size by farmers implies that farmers' earnings from social grants and agricultural activities are expected to a play crucial role on family requirements on food, health, clothing, education and agricultural inputs. On other hand, the need to take care of household members, prevents farmers from working on the farm on full time basis, it affects net farm revenue negatively.

The farming experience of farmers has presented a positive coefficient and influence on farm revenue, as the descriptive results suggest that the majority of farmers have been involved in agricultural production and activities for more than 10 years which shows that they were more experienced farmers. The farmers' experience is based on farming knowledge and information about the farming. The experienced farmers' are likely to use their farming experience and knowledge in increasing their agricultural productivity and thus furthermore increase farm revenue. The farm experience will have an impact on the farm revenue.

Distance to market inputs and output presents a negative relationship with farm revenue. The descriptive results illustrate that farmers travel long distances to purchase inputs and to sell their outputs. The regression results show that distance to input and output markets have a negative relationship with the net farm revenue of -0.035. This clearly means that the longer the distance farmers' travelled to market output and inputs, the more costs the farmers incur in terms of the money and time which negatively influences and impacts farm revenue.

Access to credit is the constraint that farmers need and require to overcome. The descriptive results suggest that farmers do lack formal access to credit and financial facilities. This is consistent with the findings of Sibanda (2014) and Pillay (2002) to the effect that a lack of

access to credit is still a major problem for smallholder farmers. This lack of access to credit leads to less capital investment on farming activities and farming techniques used which further leads to lower returns which consequently affect farm revenue. The results from Table 5.3 show that access to credit had a negative relationship with the net farm revenue. These results suggest that a lack of access to credit by farmers affects agricultural productivity and the net farm revenue negatively. These results further suggest that these farmers usually do not operate bank accounts and have difficulties to access credit offered by the banks.

Mixed crop-livestock farming is significant and positive which implies a positive relationship to the net farm revenue. The results on Table 5.1 on beta coefficient show that mixed crop-livestock farming has a greater effect on the net farm revenue. These results further suggest that applying inter-dependence strategy between crop and livestock farming will play crucial role in improving agricultural productivity and net farm revenue.

Livestock ownership has a negative and significant effect on agricultural productivity or farm revenue, which implies that there is high competition rather than complementary relationship between farming with livestock and keeping livestock as it significantly affects farm revenue. On other hand, crop production has a positive relationship with the net farm revenue. The level of education by farm heads and farmers' has a significant effect on farm revenue as the negative sign of the co-efficient implies a negative effect on farm revenue.

The use of irrigation systems was found to have a positive effect on the farm revenue and thus increases as well as improves the farm revenue. These results agree with Kurukulasuriya and Mendelsolsohn (2007) who also postulated that access to irrigation systems has a positive effect on farm revenue due to the impact it has to improving and increasing agricultural productivity and yield. This reveals the significance of mitigation strategies to offsetting the effect of climate change and variability through irrigation.

5.5.1.3 Effect of soil type on net farm revenue

The soil types were found to have a positive and negative relationship and influence on farm revenue depending on what type of a soil it is. The soil types are important in determining fertility and productivity of agricultural practices which increases farm revenue. Clay and sandy soils will influence farm revenue negatively and as a result, farm revenue will be affected and become low. However, silty soil has a positive relationship with farm revenue as it increases productivity and farm income. These results agree with Seo and Mendelsohn

(2008) on their findings that different soils have different effects on farm revenue as the above results have illustrated.

5.5.2 Marginal impact of climate change and variability on net farm revenue

Climate change varies among seasons, as the marginal effects of climate change and variability vary across seasons. The linear and quadratic variables are significant in some seasons of the year which indicates non-linear relationship between these climate variables and net farm revenue. The sign of the co-efficient whether, positive or negative, of the quadratic term indicates the relationship between climate variables and net farm revenue as inverted U-shape or U-shape. On the other hand the negative quadratic term reflects a negative relationship between the dependent variable and independent variables as well as an inverted U-shaped relationship between net farm revenue and the climate variable (Mendelsohn & Dinar, 2003). The marginal effect analysis was undertaken to observe and test the effect of change in temperatures and precipitation on net farm revenue. Table 5.2 below shows the marginal effect of temperature and precipitation.

Table 5.4: Marginal effect on net farm revenue per hectare

VARIABLES	SUMMER	WINTER	SPRING	FALL OR AUTUMN
Temperatures	-321.40	277.20	358.23	579.83
Precipitation	156.20	-350.00	-100.50	141.90

Increase in marginal temperatures during the summer season reduces the net farm revenue per hectare by R321.40 while an increase in marginal temperatures during winter; spring and autumn raises net farm revenue per hectare by R277.30, R358.23 and R579.83 respectively. The increase in temperatures during the autumn season will be conducive for the harvesting period and drying up of crops quickly; spring season will increase precipitation levels, germination enhancement and planting time while winter season will be crucial for maturation and calving period.

The marginal effect of precipitation during spring and winter seasons reduces the net farm revenue per hectare by R100.50 and R350.00 respectively. These results are consistent with Deressa's findings (2007) who observed that an increase in precipitation during the spring season enhances germination while study results revealed that an increase in precipitation

decreases net farm revenue because of low temperatures which affects germination. On other hand, an increase in precipitation in winter season decreases net farm revenue as it affects maturity of crops and livestock.

The increase in precipitation in summer and autumn increases the net farm revenue per hectare by R156.20 and R141.90 respectively. These results agree with the findings of Seo and Mendelson (2007a) who argued that net farm revenue increases with summer and autumn precipitation as farmers shift from crop to livestock, livestock to crop and diseases became less prevalent.

5.6 Summary

This study and chapter is based on the Binary regression and Ricardian approach that estimates the effect of climate change and variability on agricultural productivity. The Ricardian approach was used to estimate the effects of climate change and variability on climatic variables, soil types and socio-economic factors on net farm revenue on smallholder farmers in King Sabata Dalindyebo Municipality in the Eastern Cape Province. The Ricardian approach regressed net farm revenue against climatic variables and other explanatory variables. The regression results indicated that climatic variables, soil types and socio-economic factors have a significant impact on net farm revenue per hectare.

The results indicated that large household size, access to extension services, irrigation system, mixed crop-livestock farming, and farm experience and soil types had a positive effect on net farm revenue. Large household size appear to be associated with higher net farm revenue suggesting that there will be more labour availability and capital generation which serve as important factors of production. Thus a high concentration of household size by farmers implies that farmers earnings from social grants and agricultural activities are expected to play crucial role and on family requirements on food, health, clothing, education and agricultural inputs. The use of irrigation system and mixed crop-livestock farming was found to have a positive effect on farm revenue as they play crucial role in improving agricultural productivity and net farm revenue.

However, access to credit, livestock ownership and distance to input and output markets seem to be the limiting factors and negatively affect net farm revenue. This access to credit, livestock ownership and distance to input and output has exposed farmers to climate change and variability which leads to a decrease in net farm revenue as well as agricultural

productivity. The improvement in access to credit, livestock ownership and distance to inputs and output markets will improve agricultural productivity and net farm revenue. Policies such as climate change and variability need to invest more on improving factor endowments of smallholder farmers in order to improve performance of farmers in the face of climate change and variability.

Marginal effect analyses have indicated that increase in marginal temperatures during summer season reduces the net farm revenue per hectare while increase in marginal temperatures during winter, spring and autumn increases net farm revenue per hectare. The increase in temperatures during autumn season will be conducive for harvesting period and drying up of crops quickly; spring season will increase precipitation levels, germination enhancement and planting time while winter season will be crucial for maturation and calving period. However, the marginal effect of precipitation during spring and winter seasons reduces net farm revenue per hectare. These results reveal that increase in precipitation decreases net farm revenue because of low temperatures which affects germination.

On other hand, increase in precipitation in winter season decreases net farm revenue as it affects maturity of crops and livestock. The increase in precipitation in summer and autumn increased net farm revenue per hectare. These results show that net farm revenue increases with summer and autumn precipitation as farmers shift from crop to livestock, livestock to crop and diseases became less prevalent.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter provides the summary, conclusion and recommendations based on the study results, on the farmers' awareness with regard to climate change and variability, manifestations and effects on agricultural productivity in King Sabata Dalindyebo Municipality, in the Eastern Cape, South Africa. The objectives which were pointed out in the first chapter of the study will be used to draw up conclusions as well as making up recommendations.

6.2 Summary

The main body of the dissertation is divided into six chapters which cover the background of the study, literature review of climate change and variability, methodological framework as well as the discussion of both quantitative and qualitative results and the conclusion. The first chapter is the background of the research with research objectives, hypothesis, delineation and justification of the study. The second chapter presented the literature review of climate change and variability. It started with climate change and variability overview in agriculture and farmers' awareness, climate change and variability manifestation, the effects of climate change and variability on agricultural productivity as well as its adaptation measures. Chapter three presented a detailed description of the study area and methods applied in this research. Results are divided into two chapters, namely chapter four which gives a descriptive summary of farmers' awareness to climate change and variability and coping strategies used by farmers as well as their constraints. Chapter five presented a detailed analysis of Binary Regression and Ricardian Model which were used to test the effects of climate change and variability on farm revenue. The last chapter which is chapter six proffered the research summary, conclusion and recommendations of the study.

The study intends to contribute to the body of knowledge on climate change and variability effects as well as adaptation measures pursued by farmers. The study was conducted in King Sabata Dalindyebo Municipality, in the Eastern Cape Province, in South Africa where the focus was on smallholder farmers. The study objectives were to examine farmers' awareness of climate change and variability. The second objective was to investigate the effects of

climate change and variability to farm income. The third objective was to examine coping strategies used by smallholder farmers in King Sabata Dalindyebo local Municipality in the Eastern Cape as well as other factors that constrain them in adapting these measures to climate change and variability. The study was based on a cross-sectional data by farmers where data collection was done on 200 farmers in King Sabata Dalindyebo (KSD) Local Municipality. Results were analysed and interpreted using both descriptive statistics and empirical Binary logistic and Ricardian model analyses.

In order to achieve these objectives, the study made use of literature on climate change and variability. The literature was used for both effects and adaptation measures starting from a global, African and lastly South African perspective in order to determine farmers' awareness and effects of climate change and variability on agricultural productivity. The literature also focused on the manifestation of climate change and variability. Literature on farmers' perceptions and mitigation measures was also reviewed. The literature revealed that climate change and variability does exist and farmers' are aware of climate change and variability. Study literature further revealed that climate change and variability has undesirable effects on agricultural productivity. The study results are consistent with the literature reviewed with 94% of the farmers in KSD Municipality being aware of climate change and variability. Farmers in KSD Municipality have applied coping strategies to cope with climate change and variability effects as they had noticed changes in agricultural productivity as result of climate change and variability.

Climate change and variability brings consequences on livestock production as it negatively affects livestock production and furthermore leads to production decrease as a result. Livestock farmers in KSD as well as developing countries throughout the world are experiencing adverse effects of climate change and variability and such effects are escalating due to limited mitigation strategies and adaptation which can assist farmers in minimizing and adapting to the effects. This results in the increase in a severe decline in livestock productivity and increases the vulnerability of farmers whose livelihoods depend on livestock. Most of the farmers are aware of climate change and variability and have applied some of the coping strategies which are less costly as they cannot afford other strategies as they have financial constraints and limited knowledge about them.

The descriptive results revealed that females are the ones who are actively participating in farming and agricultural activities. In this study, people who partake in agricultural practices

and farming are elderly people since their contribution age group ranges from those who are greater/equal to 60 (>60). Most of these farmers have a household size of less than four people and the maximum is 15. Farmers in KSD municipality depended on social grants such as the old age pension, child support grants, and disability grants to support their agricultural activities which in the main are their source of income as most of people who practice agriculture are unemployed farmers who depend on agricultural production for a living and livelihoods. The income status of the study further revealed that most of the farmers who are actively in agricultural activities and partaking in the agricultural sector are elderly people who rely on old age grants to keep farming business active and going. These results indicate that the development of farming systems in the study area is likely to improve the welfare of the people in that community.

Farmers in KSD Municipality have land ownership which is advantageous and assist in improving their welfare from the income they receive from agricultural activities they are practising other than paying for land rental. Most of the farmers have land sizes of less than 3 ha and a maximum 8 ha of land. Farmers are practising mixed farming. Further, farmers have access to extension services and are members of farmer organizations which are assisting farmers in their farming constraints.

Farmers in the KSD Municipality lack market access as result of poor or no storage, transport facilities, distance to the market and market information as one of the constraints that prevent farmers from accessing markets. The study results show that apart from lacking market access, they also lack access to credit which assists in running day to day functions of the farm and purchasing inputs for their farms. The study results also revealed that farmers had access to extension officers and farmer organizations which assisted them in their constraints. Furthermore, study results showed that some farmers depended heavily on rain fed water while other farmers made use of irrigation in their agricultural production.

Farmers in the study areas were aware and perceived climate change and variability as detrimental to agricultural production as they reported various problems associated with changes and variability in climate. Farmers perceived different effects of climate change and variability on agricultural productivity as well as revealing different causes of climate change and variability where some farmers believed that human activity caused climate change and variability while other farmers believed it was the result of natural causes as God is angry with them and that it was punishment of their wrong doing.

Farmers made use of radio as their source of information with regards to changes and variability to climate. Few farmers made use of indigenous knowledge and warning indicators as their source of information with regards to climate change and variability. Farmers had experience declining in production as result of climate change and variability. They faced increases in levels of droughts, extreme temperatures, widespread diseases, widespread of pests and insects in crops, coupled with widespread diseases in crops and livestock being the most reported problems by farmers. As a result of the above mentioned effects, farmers are suffering high incidences of a reduction in crop and livestock yield. Some of the farmers reported that they were no longer growing crops such as cabbage and spinach because they are more prone pest and insects attacks whereas some totally stopped growing tuber crops because of mauls which have become active in recent years

Reports from the logistic analysis revealed that as much as farmers were aware of climate change and variability on agricultural productivity, there were factors which constrained farmers in climate change and variability on agricultural productivity. The study results revealed that gender, age, marital status, farming experience, land size, access to extension services, and income levels significantly affected farmers' awareness to climate change. Furthermore, study results showed that climate change and variability do affect agricultural productivity. Results further reveal that there is a non- linear relationship between climate variables and farm income.

Results further showed that climatic variables, water flow and socio-economic factors had a significant impact on the net farm revenue per hectare. Access to extension, household size, farm experience, mixed crop-livestock farming were found to positively influence net farm revenue. These variables were further found to contribute to an increase in agricultural productivity as well as the net farm revenue per hectare.

Livestock ownership, access to credit and distance to input and output markets were found to negatively influence net farm revenue per hectare. The improvement to access to credit is very crucial for agricultural productivity improvement and net farm revenue. The improvement in distance to input and output markets, access to credit and livestock ownership is anticipated to empower farmers by enabling them to improve their farming performance and to be competitive in the countenancing of climate change and variability.

However, even though farmers are aware and have noticed changes in climate change and variability as well as its effects on farming they still did not know much about mitigation

strategies to use and apply to counteract climate change and variability on agricultural productivity. There are few farmers who employed coping strategies and they are based on a farmer's indigenous knowledge rather than recent innovations or training which may be received from extension officers. As a result farmers employed strategies which required less knowledge and are less costly. This is due to knowledge and financial constraints that farmers have as a result of the lack of access to credit and education which farmers see as the major obstacles in their quest to adapt to climate change and variability. Such mitigation strategies are an increase in the use of increased irrigation, planting different crops, changing planting dates, crop rotation, and mixed farming, changing crop variety as well as changing the timing of operation. Livestock production farmers made use of a change in the livestock variety, stock movement, shades and ventilations and supplements livestock with feed.

6.3 Conclusion

This study explores farmers' awareness of climate change and variability and its effect on agricultural productivity in King Sabata Dalindyebo Municipality in the Eastern Cape. The study uses primary household and farmer level data enriched with secondary climate, hydrological, socio-economic and soil data. The study concentrates on Binary regression and Ricardian model to assess farmers' awareness of climate change and variability and the impact of climate change and variability on agricultural productivity per acre. The study results reveal that farmers in KSD Municipality are aware of climate change and variability and furthermore, study results suggest that climate change and variability affects agricultural productivity.

This study analysis revealed that awareness and adaptation of farmers to climate change and variability show that farming households in King Sabata Dalindyebo Municipality are aware of both short term and long term climate change and variability and above that, some farmers have implemented various adaptation mechanisms to climate variations. The analysis also shows differences in farmers' awareness and adaptations. Changes in crop to livestock, crop rotation, change timing of operations, shading/sheltering, irrigations and reduces livestock are the most common adaptation measure employed by farmers in KSD Municipality. The awareness on climate change and variability were grouped into drought and windy weather patterns; information and adaptation, climate change and extension services, and temperature. Climate change and variability affects agricultural productivity and has adverse effects on agricultural productivity through climatic conditions, soil types and lastly by household

socio-economic variables. In the model, the independent variables were tested for their significance and it was found that some variables were significant and the model's estimates fit the data at an acceptable level. Therefore, large household size, output and input markets, access to extension services, irrigation system, and soil types negatively affect net farm revenue while access to credit, farm experience, mixed farming and extension services had positive eff.

Crop, Livestock production and mixed farming, was based on a farmer's indigenous knowledge rather than recent innovations or training which may be received from extension officers, distance to input markets and annual average temperatures were the most important variables that encouraged farmers to adapt to climate change and variability. Those that did not adapt to climate change and variability cited knowledge, finance and choice of adaptation strategies as causes for not adapting to climate change. In addition, factors that increased awareness about climate change and variability as well as influenced decisions to adapt to climate change and variability were married farmers, formal extension, gender, information on climate change and variability to improve agricultural productivity.

6.4 Recommendations

1. Development of awareness programmes and climate information: most farmers lack awareness and it comes with a vast experience of farming. This calls for an urgent and speedy need to address awareness of climate change and variability among farmers as climate change and variability is happening and it has adverse effects on agricultural production. Farmers' perceptions on climate change and variability should be considered when programmes on agricultural production are planned and implemented. Programmes should and must be aligned with the way in which farmers perceive climate change and variability. This will help and assist in getting cooperation from the farmers when adaptation measures have to be implemented. Farmers perceived climate change and variability in the form of drought and extreme weather patterns. This implies that programmes must consider perceived drought and extreme weather events such as winds and extreme temperatures.

The study has acknowledged that most of the farmers lacked information with regard to climate change and variability, so the study recommends that there must be a slot created on TVs and Radios which passes such information to farmers daily and also be passed with the

use of social media. The study recommends that information with regard to weather patterns must be made available to farmers and most especially those that are staying in rural areas.

2. Development of policies: policy makers must develop policies that are aimed specifically in promoting farm level awareness which must put emphasis on the critical roles of providing improved formal extension as well as information with regards to climate change and variability. These policies will further assist in facilitating adaptation strategies to climate change and variability through educating farmers about the implications of climate change and variability for agricultural productivity.

Government together with policy makers must develop a policy which will identify and address vulnerability of farmers through the designation of adaptation frameworks and actions particularly for vulnerable regions.

3. Role of Government, policy makers and researchers: government must strengthen the system of agricultural disaster insurance in South Africa, especially in the Eastern Cape to compensate for losses experienced by farmers through drought and extreme weather events. There must be an increase in investments made on improved agricultural technology by government and policy makers which is necessary for agriculture to be in a better position to cope with climate change and variability and must be made available to smallholder farmers.

There must be an increase in research done on climate change and development of reducing carbon and such research in carbon reduction must be encouraged as it will assist in coming up with strategies that might assist in mitigating it and government must fund such research. Research and development in reduction of carbon emissions should also be encouraged. When doing research on climate change and variability, farmers and researchers must work together when taking decisions and testing opinions through research and encourage the use of farmers will be helpful as they have experience and knowledge about what must be done as farmers are the ones who will use such techniques (Musemwa *et al.,* 2012).

4. **Access to credit:** most farmers have no access to credit. Government must subsidise farmers through the provision of credit which will assist farmers with funds which they will use in purchasing advanced technologies, inputs as well as make use of improved adaptation measures to cope with climate change and variability. This will strengthen the ability of farmers to acquire agricultural inputs and improved techniques and furthermore, access to credit will increase adoption of adaptation strategies (Mcata, 2012).

5. Access to extension services and training: Firstly government must embark on training extension workers about new technologies and techniques to improve agricultural productivity as well as training extension workers about climate change and variability. Extension workers, together with government must embark on training which will increase awareness and knowledge about climate change and variability and making use of extension officers to provide necessary changes to farming techniques which assist farmers in adapting to climate change and variability phenomenon. Government and extension offers must promote and encourages farmers to make use of local breeds (such as Nguni) and use of Angus, Bosmara and Nguni as they are easily adaptive to harsh conditions, poor quality grazing and extensive heat and humidity conditions. The use of extension agents which serve as middleman between farmers and government through passing of information must be encouraged and be assigned to pass messages about climate change and variability, market information as well as promoting farm records. Extension officers and government must visit farmers regularly and also provide information on current issues related to farming, new technology development for agriculture and farming, climate change and variability issues, training about new agricultural techniques to counteract climate change and variability effects in farming, provide market information and storage facilities. This will be achieved through strengthening of the country's and provincial's extension services through devolving the mass of the services down to the local councils and chiefs, which are closer to the farmers (Montshwe, 2006).

6. Infrastructural development: government and policy makers must develop infrastructure for farmers which is one of the components of vulnerability of farmers to climate change and variability due to low infrastructural development, lack of access to farming techniques and implements and low market access. This study calls policy makers to build physical infrastructure which are transport structures, marketing and communication systems as results indicates that most farmers lack market access and poor roads to input and output markets, which these poor infrastructure leads to lack of adaptation. The intervention by policy makers and government is to enhance infrastructural development. The improvement in infrastructure development will play crucial role in improving agricultural productivity through infrastructure development such as new techniques as well as coping with climate change and variability as such techniques will minimize climate change and variability effects on agricultural production (Mphahama, 2011).

7. Disaster and agricultural insurance: as many farmers lose their production through disasters and extreme weather events which largely affect their livelihoods and farming, there must be an increase and strengthening of disaster insurance in agriculture as farmers are experiencing looses of agricultural production through drought persistence and extreme weather events as a result of climate change and variability, stock theft, death.

Farmers' organizations must encourage farmers to form farmer groups and organizations to enhance the capacity through group efforts and such groups and organizations will assist them in taking advantage of the internet and access to credit to improve agricultural techniques used. The farmers' organizations mainly aim at developing smallholder farmers and encourage farming through the provision of information, agricultural techniques, trainings and services as part of development for sustainability amongst small holder farmers.

8. Irrigation systems: Most of smallholder farmers in KSD Municipality depend on rain-fed water for farming, climate change and variability which affects such farmers as it brings drought tolerance and high temperatures. There is a need and emergency to depart the ever reliance of rain-fed water by farmers for agricultural productivity through heavy introduction and utilization of irrigation. Thus therefore government together with policy makers there is a need for adequate provision of irrigation and drainage infrastructures which must be regarded as crucial strategy to be used by farmers in mitigating climate change and variability and it must be introduced and implemented (Montshwe, 2006). Farmers in KSD Municipality must be trained and taught about irrigation systems which will improve agricultural productivity as it responds positive to productivity and easy to use. Policy makers and government must invest on irrigation systems as most of the farmers in KSD do not make use of irrigation system and it further assist by being a coping strategy to cope with climate change and variability. Building of dams must be encouraged to farmers as dams will assist in providing water for irrigation

6.5 Areas of further research

Even though study results indicate that the majority of farmers in King Sabata Dalindyebo Municipality are aware of climate change and variability as well as its effects on agricultural productivity, more elaborate research is necessary to accurately quantify the awareness and effects of climate change and variability, the adaptation strategies to mitigate the level of climate change and variability on smallholder farming. In addition, government and policy

makers must subsidise studies and research done on climate change and variability effect so as to encourage researchers as well as drawing up adaptation measures that are essential for coping with this climate change and variability phenomenon in agricultural production.

A similar study can be conducted at the provincial level so as to build a conclusive picture of farmers' awareness and effects of climate change and variability on agricultural productivity as well as examining different coping strategies used by smallholder farmers in coping with climate change and variability, as to enable policy makers in decision making of what adaptation measures must be applied to mitigate climate change and variability. In this study and in light, the study results at this phase should be considered as tentative and partial.

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APPENDIX: QUESTIONNAIRE

FACULTY OF SCIENCE AND AGRICULTURE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

TITLE: FARMERS' AWARENESS OF CLIMATE CHANGE AND VARIABILITY ON AGRICULTURAL PRODUCTION: THE CASE OF KING SABATHA DALINDYEBO MUNICIPALITY IN EASTERN CAPE.

NB: THE INFORMATION PROVIDED BY THESE INTERVIEWS WILL BE FIRMLY CONFIDENTIAL.

1. Brief general information

1.1 Name of the interviewer:.....

1.2 Municipality: .....

1.3 Name of farmer (Optional):….....

1.4 Ward number……..

1.5 Date of the interview…….……

1.6 For how long have you been a farmer?…….……

2. Household information

2.1 Gender: Male ☐ Female ☐

2.2 Age: ☐

2.3 Marital status: Single ☐ Married ☐ Window ☐ Other (specify)…….

2.4 Level of education: Primary ☐ Secondary ☐ Tertiary ☐
Other (specify).....

2.5 Household size: 1-3 ☐ 4-8 ☐ 9-15 ☐ > 15 ☐

2.6 Employment status: Unemployed ☐ Employed ☐ Self- employed ☐
Other (specify)……..

2.7 Level of income monthly: 0-500 ☐ 600-1000 ☐ 1000-2000 ☐

< 2000 ☐

2.8 For how long you have been in farming business?.....

2.9 Which communication networks do you have access to?

Internet ☐ Radio ☐ Cell phone ☐ Newspapers ☐ Other (specify) ☐

3. Household sources of income

3.1 What are your Household's sources of income?.

Source of Income	Amount
1. Agricultural activities	
2. Salaries	
3. Old age pension	
4. Child support grant	
5. Disability grant	
6. Remittance	
7. 0ther (specify)	

4 Agricultural Production

4.1 Land Ownership

Make use of X where possible to answer the following questions

4.1.1. How much land do you have access to?.....

4.1.2 How much of it is arable?.....

4.1.3 What is the tenure of this land? Freehold ☐ Leased ☐ Private ownership ☐

Communal ownership ☐ Community ownership ☐

4.1.4 Type of soil the farmer uses:

Sandy ☐ Silty ☐ Clay ☐ Saline ☐ Peaty ☐

4.1.5 Which means of cultivation you use: Hand ☐ Animal Traction? ☐

Tractor ☐

4.1.6 How much land did you use last season?.....

4.1.7 What did you produce last season?

Crops/ Vegetables ☐ Livestock ☐ Mixed ☐

4.1.8 Do you keep farm records?

Yes ☐ No ☐

4.2 Cropping Farming

A1	A2	A3	A4	A5	A6	A7
Does the farmer have access to arable land? 1.Yes 2.No	**Is the HH owning or renting the arable land?** 1.Owning 2. Renting 3.Other (Specify)	**Approximately how many hectares is this arable land?** 1. 0.5 ha– 1 ha 2. 1.5 to 2 ha 3. 2.5 ha to 3 ha 4. 3.5 ha to 4 ha 5.Other (Specify)	**Does the HH use the arable land for own food production? (engaging in crop farming)** 1.Yes 2.No	**List the crops produced by HH** 1.Onion 2.Potatoes 3.Cabbage 4. Spinach 5. Carrot 6. Maize 7 Peas 8 Beetroot 9 Lettuce 10 Pumpkins 11 Pepper 12.Other (Specify):	**How much quantity produced?**	**How much quantity is for HH use?**

A8	A9	A10
How much quantity is sold?	**How much quantity is for donations?**	**Which commodity is being highly consumed?**

4.2.2 Do you irrigate your crops? Yes ☐ No ☐

4.2.3 Do you practice special cropping? Mixed farming ☐ Mono-cropping ☐

4.3 Livestock Farming

A11	A12	A13	A14	A15	A16	A17	A18
Do you keep animals for farming? 1.Yes 2.No	**List those animals do you keep for farming** 1.Cattle 2.Sheep 3.Goats 4.Chickens 5.Pigs 6.Horses 7.Ducks 8.Other (Specify)	**How many animals do you owned as the farmer (animal: number owned)?**	**How many animals do you use for home consumption use?**	**How many animals do you sold?**	**How many animals do you donate**	**How many animals do you use for rituals (lobola, ceremonies etc)**	**How many animals do you use and keep for drought power?**

5. MARKET INFORMATION, ACCESS TO CREDIT, EXTENSION SERVICES AND FARMER ORGANIZATION.

5.1 Market access

A21	A22	A23	A24	A25	A26	A27
Do you have access to marketing information prior to sales? 1.Yes 2.No	**If Yes, what are your sources of information?** 1.Radio 2.Television 3.Extension publications 4.Government extension officers 5.NGO extension officers 6.Other (Specify)	**How far is it to get to your main market outlet? State in km**	**How do you transport your produce To the market?** 1.Own transport 2.Public transport 3.Hired transport (Individual) 4.Hired transport (Group) 5.Buyer transport it 6 Trucks 7.Other (specify)	**Do you encounter transport problems when selling/taking your produce to the markets?** 1.Yes 2.No	**What problems do you face in transporting your produce?** 1.Small size of transport 2.Lack of transport 3.High transport cost 4.Other (specify)	**Do you have any access to road infrastructure?**

A28	A29	A30	A31	A32	A33	A34
Do you have any access to road infrastructure? Yes No	**Do you have access to markets (formal or informal) where to sell your produce?** Yes No	**Where do you market your crop Produce?** Locally (informal) Hawkers (informal) Fruit and Vegetables Supermarkets Wholesale Greengrocers Agro-processors National Fresh Produce Markets (FPMs) Other (specify)	**Which channel do you use to sell your livestock?** Auction Butcheries Abattoirs Private sales Speculators Other (specify)	**Do you fatten your cattle before taking them to the Market?** Yes No	**Give reasons for that**	**Do you sell your produce as the group (whether crop or livestock)** Yes No

A35	A36	A37	A37
Is your produce graded before it goes for sales? Yes No	**If Yes, do you have problems meeting the grading standards?** Yes No	**What happens to the produce with poor grade?**	**How much do you pay for transporting your produce?**

5.2 Access to Credit

A39	A40	A41	A42	A43	A44
Do you need credit for your production enterprise? Yes No	**Do you have access to any production loans e.g. capital?** Yes No	**Have you ever been denied a production loan?** Yes No	**If 'Yes', what were the reasons?** Lack of invoices of what has been sold Non residency of the community Lack of a performing account Lack of collateral or security (physical assets	**Which sources of credit do you have Access to?** commercial banks (Formal) agricultural cooperatives (Formal) Land bank Credit Union	**Do you have any access to labour?**

			-farm machinery and livestock) Other (Specify)	Other (Specify) (Informal)	

5.3 Access to extension services

A45	A46	A47	A48	A49	A50	A51
Have you ever received any assistance from extension workers Yes No	**How often did extension officers visit your farm?** Once a week Once a month Never Other (Specify)	**How often did extension officers visit you in production and marketing periods (in months)?** Once Twice Three Other (Specify)	**What services does he/she provide?** Advice on crop production Advice on marketing Advice on record keeping Advice on climate change issues Advice on other services	**What type of extension officer do you have access to?** Government extension officers NGO extension officers	**Do extension officers provide you with changes in farming practices and new technologies?** Yes No	**How do you view the quality of the extension service that you receive?** Excellent Very good Satisfactory Poor Very poor

			Other (Specify)			

5.4 Farmer organization

A52	A53	A54	A55	A56	A57
Are you an affiliated member of a farmers' association? Yes No	**If yes, which one(s) are you affiliated to? Provide:** Input supply services Extension Veterinary service Training services Credit supply/financial institutes Transport/distribution Marketing services Police services	**What does the association do for you?**	**If 'Yes', are you satisfied with the association in terms of general information provision?** Yes No	**If 'No', please give reasons why?**	**What are the benefits of being a member of this organization?**

6. FARMERS' AWARENESS OF CLIMATE CHANGE AND VARIABILITY ON AGRICULTURAL PRODUCTION

6.1 Knowledge on climate change and variability

6.1.1 Have you ever heard anything regarding to climate change and variability?

Yes ☐ No ☐

6.1.2 If yes, what was the source of this information?

Government officers ☐ Friend ☐ Radio ☐ Television ☐

Newspaper ☐ School ☐ NGOs ☐ Village meetings ☐

Internet search ☐ Others (Specify)……..

6.1.3 If yes, what can you say is the cause of climate change and variability?

Human activity ☐ Natural activities ☐

6.1.4 Have you noticed any changes in temperature?

Yes ☐ No ☐

6.1.5 Have you noticed an increase or decrease or constant in average rainfall amounts over the long-term?

Constant ☐ Increase ☐ Decrease ☐

6.6 Has the timing of rainfall in the seasons been shifting over these long-term?

Yes ☐ No ☐

6.7 Have incidents of heavy rain, droughts, frost, dry spells and hails been increasing or decreasing over the long-term?

Increasing ☐ Decreasing ☐

6.1.7 Do you have access to any climate and variability information?

Yes ☐ No ☐

6.2 Training on climate change and variability

5.2.1 Have you ever received training focusing on climate change issues?

Yes ☐ No ☐

6.3 Indigenous knowledge and indicators on climate change

6.3.1 Do you have local means of forecasting weather?

Yes ☐ No ☐

6.3.2 To what extent do you rely on weather predictions made through indigenous knowledge?

Not reliable ☐ Reliable ☐ Very reliable ☐

6.3.3 What are the indigenous warning indicators for changes in weather?

Nesting position of certain birds specie ☐ Cry of Frog ☐

Abundance of insects ☐ Shift of the moon position ☐

Abundance of wild fruits ☐ Others, Specify……

7 THE CHANGES THAT FARMERS NOTICE AS A RESULT OF CLIMATE CHANGE AND VARIABILITY ON AGRICULTURAL PRODUCTION OVER LONG-TERM

7.1 Please indicate whether the agricultural productivity is Increasing or due to climate change problem experienced

Increasing: 1, Decreasing: 2,

The problem	Increasing/ Decreasing
1. Livestock production (is production increasing or declining)	
2. Are diseases in livestock increasing	
3. Does mortality in livestock rising/ increasing	
4. Crop production level (is it increasing, decreasing or failing)	
5. Are diseases in crops spreading	

6. Is there a wide spread of insects and pests in crops	
7. Other (specify)	

7.2 Please indicate the cause of such problem which causes agricultural Productivity to increase or decrease.

Drought: 1, Floods: 2, Extreme temperatures: 3 Other (Specify): 4

The problem	Cause of such Problem
1. Livestock production (is production increasing or declining)	
2. Are diseases in livestock increasing	
3. Does mortality in livestock rising/ increasing	

8. Does mortality in livestock rising/ increasing	
9. Crop production level (is it increasing, decreasing or failing)	
10. Are diseases in crops spreading	
11. Is there a wide spread of insects and pests in crops	
12. Other (specify)	

7.3 What are coping strategies you use to with cope such problems in agricultural productivity as a result of climate change and variability?

The problem	The coping strategy to cope with it or mitigation strategy
1. Livestock production (is production increasing or declining)	

2. Are diseases in livestock increasing	
3. Does mortality in livestock rising/ increasing	
13. Does mortality in livestock rising/ increasing	
14. Crop production level (is it increasing, decreasing or failing)	
15. Are diseases in crops spreading	
16. Is there a wide spread of insects and pests in crops	
17. Other (specify)	

8The reaction of farmers to climate change and variability

8.1 Do you regard climate change and variability a threat to farming?

Yes ☐ No ☐

8.2Do you think is it important to make use of adaptation measures in response to variability and climate change on agricultural production?

Yes ☐ No ☐

8.3Have you made any changes in farming practise in response to variability and climate change on farming?

Yes ☐ No ☐

8.4The indigenous and conventional adaptation strategies

8.4.1Due to noting early of warning signs related to climate change and variability (e.g. drought), what are indigenous ways of responding to such situation?

Pray and offer to Ancestors ☐ Pray to God ☐ Invite traditional mediums or doctors Others, Specify……

8.4.2What additional measures would a farmer consider in the future to counteract variability and climate change in agricultural production.

8.4.2.1 Please mark the additional measure that you use to counteract or mitigate climate change and variability in agricultural production

The coping strategy	Mark it with X
Change crop variety	

Change livestock variety	
Change the timing of operation	
Crop rotation	
Increase irrigation	
Change from crop to livestock	
Reduce livestock number	
Supplement livestock feed	
Diversify the income generating and livestock activities	
Increase awareness through education	
Innovate agricultural practices and technology	

Forest sustainability	
Increase co-operation among farmers	
Avoid monoculture encourage farmers to plant a variety of drought resistant crops	
Develop new crop types and seed banks	
Disperse information on conservation management practice	
Change from crops to livestock	
Change from livestock to crops	
Different planting dates	
Crop diversification	
Other (specify)	

8.4.3 Please indicate the importance of the strategy you selected above as to mitigate climate change and variability on agricultural productivity.

The coping strategy	The importance of it
Change crop variety	
Change livestock variety	
Change the timing of operation	
Crop rotation	
Increase irrigation	
Change from crop to livestock	
Reduce livestock number	
Supplement livestock feed	

Diversify the income generating and livestock activities	
Increase awareness through education	
Innovate agricultural practices and technology	
Forest sustainability	
Increase co-operation among farmers	
Avoid monoculture encourage farmers to plant a variety of drought resistant crops	
Develop new crop types and seed banks	
Disperse information on conservation management practice	
Change from crops to livestock	

Change from livestock to crops	
Different planting dates	
Crop diversification	
Other (specify)	

8.5What are the constraints that you faced in changing your farming system/practice?

Finance ☐ Knowledge ☐

These questions are for those farmers that do not take any coping strategies

8.6Do you consider taking coping strategies in response to variability and climate change in nearby future?

Yes ☐ No ☐

8.6If yes, which farm practise on the list below you have employed and what is the function of the strategy you have employed?

Mitigation strategy	Mark with X
Crop rotation	
Change crop variety	

Change from crop to livestock	
Reduce livestock numbers	
Increase irrigation measures	
Change livestock variety	
Change timing of operation	
Supplement livestock with feed	
Change from livestock to crops	
Crop diversification	
Diversify the income generating and livestock activities	
Others (specify)	

8.7 What are the constraints you faced when employing coping strategies in response to variability and climate change in agricultural production?

Finance ☐ Knowledge ☐

8.8 What assistance will you prefer and like to receive in order to be able to counteract with climate change and variability so that you can employ coping strategies?

9 Data for calculation of Net Farm Income (V) for the past growing season (dependent variable in the Ricardian Model)

Income	**Amount ®**
A_1 Sales of grain	
A_2 Sales of livestock bought for resale	
A_3 Sales of raised livestock	
A_4 Value of product fed to livestock	
A_5 Value of product consumed at home or donated	
A_6 Sales of breeding livestock	
A_7 Livestock slaughtered for home consumption and donated	
A_8 Other income	
A_9 GROSS FARM INCOME $(A_1+A_2+A_3+A_4+A_5+A_6+A_7+A_8)$	

Expenses in the farm

Cash expenses	**Amount(R)**
Feed purchase	
Seed purchase	
Chemicals	
Fertilizers	
Machinery (fuel, oil, gasoline)	
Implements (repairs and maintenance)	
Casual labor (labor hired)	
Rent payments	
Storage and warehouse	
Packing material	

Veterinary and medicine	
Hired transport	
Marketing costs	
Other expenses	
B TOTAL CASH EXPENSES	

C NET FARM INCOME FROM OPERATIONS (A_9 – B)	