Smallholder farmers' perceptions and adaptation to climate change interventions and support systems in Limpopo province, South Africa.

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ABSTRACT

Climate change is one of the most critical long-term global challenges, especially for Africa and even more so Southern Africa. Agriculture is more than an economic cornerstone of most rural households in sub-Saharan Africa and climate change variations pose a threat to the agricultural sector and food security of these households. Climate variations such as increased hot seasons have been reported to lead to loss in food production through crop failure, human disease outbreak and livestock deaths. Several initiatives to develop climate change interventions and support systems are reported, however, it is not known if they are reaching and benefitting the smallholder farmers who are vulnerable to climate change. The study investigated smallholder farmers' perceptions and adaptation to climate change interventions and support systems in Mopani and Vhembe districts, in Limpopo province, South Africa. Hundred and fifty questionnaires were administered to smallholder farmers who were subsistence farmers who produced for household consumption and only seldom sold; those who were farming for both household consumption and selling the surplus; and those who were mainly selling referred to as *'food producers'* because their primary goal was to produce for the market. Eight focus group discussions were conducted to collect in-depth information on smallholder farmers' perceptions towards climate change support systems, interventions and experiences towards climate change. Transect walks were done with a small group of farmers from four local municipalities to observe if the farming production systems and practices of the farmers were adapting to climate change and to probe on what influenced their decisions.

The study findings revealed that crop production was regarded as a way of life for smallholder farmers in Limpopo province, especially amongst women farmers (72%), as it contributed to household food security and 73,3% famers also sold surplus to generate livelihoods. The farmers perceived prolonged droughts (56.4%) as the main shock stressing their production whilst other farmers were of the opinion that very hot seasons were the significant shock (56%). The focus group discussions revealed that the smallholder farmers had different perceptions of climate change and the majority of smallholder farmers perceived climate change to be caused by supernatural forces. Only a minority adapted to climate change, by changing planting dates and intercropping. However 42% did not adapt due to water shortages and 67.3% were not aware of

climate change interventions and were not receiving any climate change support. Consequently, almost all the farmers (78%) relied more on their indigenous knowledge for resilience to climate change. However, female smallholder farmers seemed to be more vulnerable to climate change impacts due to their age, health status and high level of illiteracy as compared to their counterparts male farmers, hence they were hit hard by the climatic variability and experienced measurable crop losses (68.7%). In response to the prevailing climatic condition different gender adapted different strategies, 41% of female farmers adapted to changing planting dates, while male farmers employed crop variety and diversification (35%) and mixed cropping (15%) better than female farmers. Therefore, this means there is a need to bring awareness of the implications of climate change to the farmers.

There is a need to consider indigenous knowledge system-based climate change support and interventions to empower farmers with capacity to withstand climate change challenges. To encourage farmers to adopt climate-smart agriculture technologies, which can be achieved through creating and enabling policy environment for adaptation, the government also need to invest in smallholder farmers skill audits programme, in the long run, so that these farmers graduate from just being subsistence farmers and food producers to commercial farmers.

PREFACE

The work described in this dissertation was carried out in the school of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, from February 2015 to December 2015, under the supervision of Prof. Paramu Mafongoya and Dr Unathi Kolanisi.

Signed: _____ Date: _____

Nomcebo Ubisi (Candidate)

As supervisors of the candidate we agree to the submission of this dissertation.

Signed: _____ Date: _____

Prof. Paramu Mafongoya (Supervisor)

Signed: _____ Date: _____

Dr Unathi Kolanisi (Co-supervisor)

DECLARATION

I, Nomcebo Rhulani Ubisi, declare that:

i. The research, except where otherwise indicated, is my original research.
ii. This dissertation has not been submitted for any degree or examination at any other university.
iii. This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from those persons.
iv. This dissertation does not contain other authors' writing, unless specifically acknowledged as being sourced from other authors. Where other written sources have been quoted, then:
    a) Their words have been re-written but the general information attributed to them has been referenced
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v. This dissertation does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, with the source being detailed in the dissertation and in the references section.

Signed: _____ Date: _____

Nomcebo Rhulani Ubisi (Candidate)

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Abbreviations

ADB	Asian Development Bank
ASFG	African Smallholder Farmers Group
CAADP	Comprehensive Africa Agriculture Development Programme
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture Forestry and Fisheries
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DEDEA	Department of Economic Development and Environmental Affairs
DSD	Department of Social Development
EEA	European Environment Agency
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GCCC	Government Committee on Climate Change
GDP	Gross Domestic Product
HSRC	Human Sciences Research Council
IDP	Integrated Development Plan
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
NASA	National Aeronautics and Space Administration
NCCC	National Climate Change Committee
NEPAD	New partnership for Africa's Development
SAG	South African Government
SPSS	Statistical Package for Social Sciences
SDG	New Sustainable Development Goals
UN	United Nations
UNDP	United Nations Development Programme
UNEP	Unite Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WWF	World Wide Fund

Chapter 1: THE PROBLEM AND ITS SETTING

1.1 Introduction to research problem

Climate variability and change is an important phenomenon that requires close attention, as it directly influences the food supply and livelihoods of billions of people. According to Watson (2010), the earth has warmed by an average of 0.7^0 C over the past 100 years with the 1990s and 2000s being the warmest. The challenges of climate change are continuously increasing with rural communities being the most vulnerable, affecting their livelihoods. Unfortunately, these variations are projected to worsen in the next decades (IPCC, 2007). Thus, it is important to understand climate change challenges especially amongst smallholder farmers' since agriculture is an essential component of their social well-being. For these agricultural dependent vulnerable groups, even minor changes in climate can have disastrous impacts on their lives and livelihoods**.**

About 70 percent of sub-Saharan Africa's smallholder farmers rely mainly on agriculture as the main source of livelihood (AGRA, 2013). Literature confirms that smallholder agriculture drives rural economic growth and welfare for the poor (Komba and Muchapondwa, 2012). The smallholder agricultural sector, therefore, holds great potential to ensure accessible nutritious food to meet people's dietary needs, reduce rural poverty and enhance livelihoods (Nyiraneza, 2007; IFAD, 2008). Deressa *et al.,* (2009) and Apata *et al.,* (2009) state that sub-Saharan Africa is one of the vulnerable regions to climate change. Climate change variability has negatively affected agriculture and the farming practices of smallholder farmers resulting to food insecurity. The situation has become dire because most smallholder farmers across sub-Saharan Africa are found in substandard marginal semi-arid land relying heavily on rain-fed crops with poor soil exposing them to climatic shocks. The smallholder farmers' vulnerability status is further worsened by the continent's poor economic development and low adaptive capacity (IFAD, 2008). In the face of broad macroeconomic constraints and lack of local level adaptation policies, smallholder farmers tend to use their indigenous knowledge to address climate change and variability impacts (Kolawole *et al*., 2014).

Smallholder farmers, unlike their commercial counterparts, struggle to adapt to climate change due to low incomes, weak institutions, low levels of education and primary health care, lack of markets and infrastructure and already-degraded ecosystems (Osbar *et al.,* 2010). Hazell *et al.,* (2007) highlighted that smallholder farmers have less access to human, social, financial capital and information than commercial farmers to avert against climatic risk. Apata *et al.,* (2009) stated that smallholder farmers in semi-arid areas practice mainly rain-fed farming and have little access to irrigation facilities. In these regions rainfall is unevenly distributed with an average annual rainfall of about 500mm or less, causing poor moisture availability for crops, resulting in low crop yields and increased vulnerability of the smallholder farmers (Churi *et al.,* 2013). Smallholder farmers, therefore, need to make critical cropping decisions in a particular season. It is, thus, important for smallholder farmers to understand and have access to information on seasonal weather forecasts in order to cope and adapt to changing weather patterns. However, smallholder farmers in South Africa are resource poor and lack institutional support, they do not get the support they need from extension officers, hence it is difficult for them to cope and adapt (Mudhara, 2013). Therefore, smallholder farmers may be at a disadvantage with more exposure to climatic shocks aggravating their vulnerability. On the contrary, the commercial farmers are adopting new strategies such as crop diversification and changing planting times and harvesting dates as potential adaptation strategies to climate change, as well as and receiving support systems from the government such as infrastructure, health and risk reduction; and knowledge management (Below *et al*., 2010). This situation, therefore, calls for smallholder farmers to adopt adaptation measures to reduce the negative effects caused by climate change and variability, especially on crop production.

More so, the effects of climate change have been reported to affect men and women differently (Geijn *et al.,* 2011). Women, children and the elderly are found to be the most vulnerable to climate change impacts, mainly because women play a crucial role in providing food security for their families (Cherotich *et al*., 2012; Alexander *et al.,* 2011). In sub-Saharan Africa alone, women make up almost 50 percent of the agricultural activity, which decreased from about 50% to 35% from 1994 to 2008 due to climate related circumstances (Doss, 2011).The study conducted by Cherotich *et al*., (2012) revealed that there are different channels used to disseminate climatic information to farmers, and it was found that there are different preferences in accessing climate change information between men and women. Some of the existing methods

for communicating information to smallholder farmers include radio, television, extension officers and face-to-face communication (Churi *et al.,* 2012). Moreover, Cherotich *et al.*, (2012) revealed that women preferred radio whilst the elderly people preferred local indigenous knowledge. However, CGIAR (2014) indicated that women preferred to access information from extension officers, through more personal contact than men, who preferred radio.

In South Africa climate change is threatening the food security agenda of the country (HSRC, 2014). As stated by Deressa *et al.*, 2009) the effect of climate change is felt amongst all farmers both commercial and smallholder levels. However, smallholder farmers are hit hard due to their high dependency on climate-sensitive natural resources for their livelihoods. An increase in natural disasters and climate hazards, water scarcity, diseases and reduced agricultural production has been one of the key observations that farmers noted. Low-input farming systems, extreme weather conditions associated with climate variability coupled with the country's already scarce water resources, are some of the obvious impacts of climate change on agricultural activities (Turpie and Visser, 2013).

The impact of climate shocks in South Africa is predicted to increase food insecurity and worsen the poverty status among rural communities' placing some communities more sensitive to these changes than others (Turpie and Visser, 2013). Provinces that have been identified as high poverty and food insecure nodes include Limpopo, Mpumalanga, Eastern Cape and KwaZulu-Natal (DPLG et al., 2007). In the wake of climate change these provinces are more susceptible, sensitive and vulnerable due to the large numbers of smallholder farmers who depend on agriculture for their livelihoods. Moving beyond the 21st century climate change poses to be the major threat to smallholder farming systems and food security. There is a noticeable rigorous research, dialogues and technology innovation development to deal with climate changes at global and regional level (IPCC, 2007, 2013). However, there is little known about how smallholder farmers perceive climate change and variability; how they access climate and seasonal weather information; and how they make decisions based on the information they obtain. Therefore, this study aims to explore smallholder farmers' perceptions and adaptation strategies towards climate change interventions and support systems in Limpopo province.

1.2 Importance of the study

In developing countries rural communities are the most neglected in terms of government service delivery and are the most impoverished (Churi *et al.,* 2013). Studies have shown that smallholder farmers in rural communities have limited access to capital and technology, information, inadequate public infrastructure, such as roads, long term weather forecasts and inadequate research and extension (DAFF, 2012). Therefore, understanding how rural smallholder farmers perceive climate change and variability and support systems would facilitate a better understanding of how these farmers mitigate and adapt to the negative impacts of climate change. Several studies on the impacts of climate change on smallholder farmers have been conducted in South Africa (Maponya and Mpandeli, 2013; Turpie and Visser, 2013; Ziervogel *et al.,* 2014); however, few studies have been conducted on farmer perceptions and adaptation strategies on climate change interventions and support systems in Limpopo province. Better insight on this subject would yield more information to understand whether smallholder farmers are aware of the support systems made available to them, and if they have easy access to them. Understanding how smallholder farmers cope with and respond to climate change would enable policy makers to enhance and develop policies and strategies that could help smallholder farmers to cope and adapt to these changes. Having insight on smallholder farmers' perceptions towards climate change would enhance current strategies and interventions to ensure successful adaptation strategies.

1.3 Overall aim:

The aim of the study was to determine the smallholder farmer's adaptation strategies and their perception towards climate change interventions and support systems.

1.4 Specific Objectives

- To determine climatic and non-climatic shocks faced by smallholder farmers.
- To evaluate smallholder farmers' understanding and awareness of climate change related interventions and support systems.
- To assess smallholder farmers' perceived usefulness of climate change related interventions and support systems in terms of availability and accessibility.
- To determine the smallholder farmers climate change adaptation strategies and what informs them.

1.5 Study limits

- The results of the study may not be generalized since the study was carried out in one province

1.6 Assumptions

The following assumptions were made:

- It was assumed that all participants answered all survey questions honestly
- It was also assumed that the focus group participants gave honest responses during the discussions

1.7 Definition of terms

Adaptation:

Adaptation involves initial plan and measures to reduce the vulnerability of natural and human Systems against actual or expected stresses (UNEP, 2009)

Climate Change:

A change of climate which is directly or indirectly caused by human activity that changes the composition of the global atmosphere, and persists for a long period of time, usually decades or longer (CSIR, 2010)

Food Security:

Food security is when food is available for all people (present and future generation) at all times, and it is physically and economically accessible to them, safe and nutritious food that meets their dietary needs and their preferences for an active and healthy life (FAO, 2013).

Indigenous Knowledge System

Is the information and skills gathered from the local communities usually based on culture, that have been used as indictors and prediction measures of some upcoming events or situations.

Mitigation:

It is the effort to eliminate or reduce the effects or severity exposure to risks and disasters (FEMA, 2015).

Smallholder Farmers:

Smallholder farmers are also known as small-scale farmers; they usually have limited resource and own a small-based plot of land (DAFF, 2014).

Resilience:

The ability of an affected community to withstand against disasters and have the potential to recover from it (FAO, 2015)

Vulnerability:

Group of people that are easily harmed or affected by natural hazards and find difficulties to cope with the situation (IFRC, 2013)

1.8 Organization of thesis

The thesis is laid out as follows:

- Chapter 1 provides the introduction and background to the research problem and the objectives investigated in this study.
- Chapter 2 reviews the literature on climate change and its impacts on rural livelihoods of smallholder farmers, as well as the perceptions of smallholder farmers on climate change, their adaption strategies and available climate change interventions and support systems.
- Chapter 3 presents the study conceptual framework and description of the study area, and the methodology used to collect and analyze data.
- Chapter 4 and Chapter 5 are research chapters; Chapter 4 presents results on availability, awareness and accessibility of climate change interventions and support to smallholder farmers' in Limpopo province. Chapter 5 reports on the perceived effects of climate change on crop production and household livelihoods in rural Limpopo province, South Africa.
- Chapter 6 presents the conclusions and recommendations.

Chapter 2: LITERATURE REVIEW

2.1 Introduction

Literature reviewed in this chapter further elaborates on the impact of climate change and variation on rural livelihoods. Smallholder farmers' perceptions and adaptation strategies to climate change and variability are also reviewed. Lastly, climate change interventions and support systems for smallholder farmers would be discussed.

2.2 Climate change conceptual framework

Climate is the average weather of a certain region or place over a long period of a decade or more (NASA, 2011; FAO, 2008). Climate change is any change in climate over a long period of time, whether due to natural variability or a result of human activities (ADB 2015; UNFCCC, 2011; IPCC, 2013; WWF, 2015). The world today is experiencing extreme temperatures, droughts, floods, rising sea levels, melting snow and storms caused by the rising levels of carbon dioxide and other heat trapping gases in the atmosphere thus warming the earth (DEA, 2010; UNFCCC, 2011; Mulkern and Climate-Wire, 2013). The IPCC (2013) argues that these climatic changes have a negative impact on people's livelihoods, agriculture, freshwater supply and other natural resources that are important for human survival. Climate change has been reported to have caused negative impacts on crop production, especially among the vulnerable groups residing in rural settings namely smallholder farmers who depend on agriculture for their livelihoods (Turpie and Visser (2013).

Figure (1) shows the conceptual construct of this study. Smallholder farmers can only make decisions for adaptation to climate change based on their perceptions of the climate risk as well as exogenous policies on climate change (Figure 1). However, their adaptation is also affected by other non-climatic factors which include social and economic constraints.

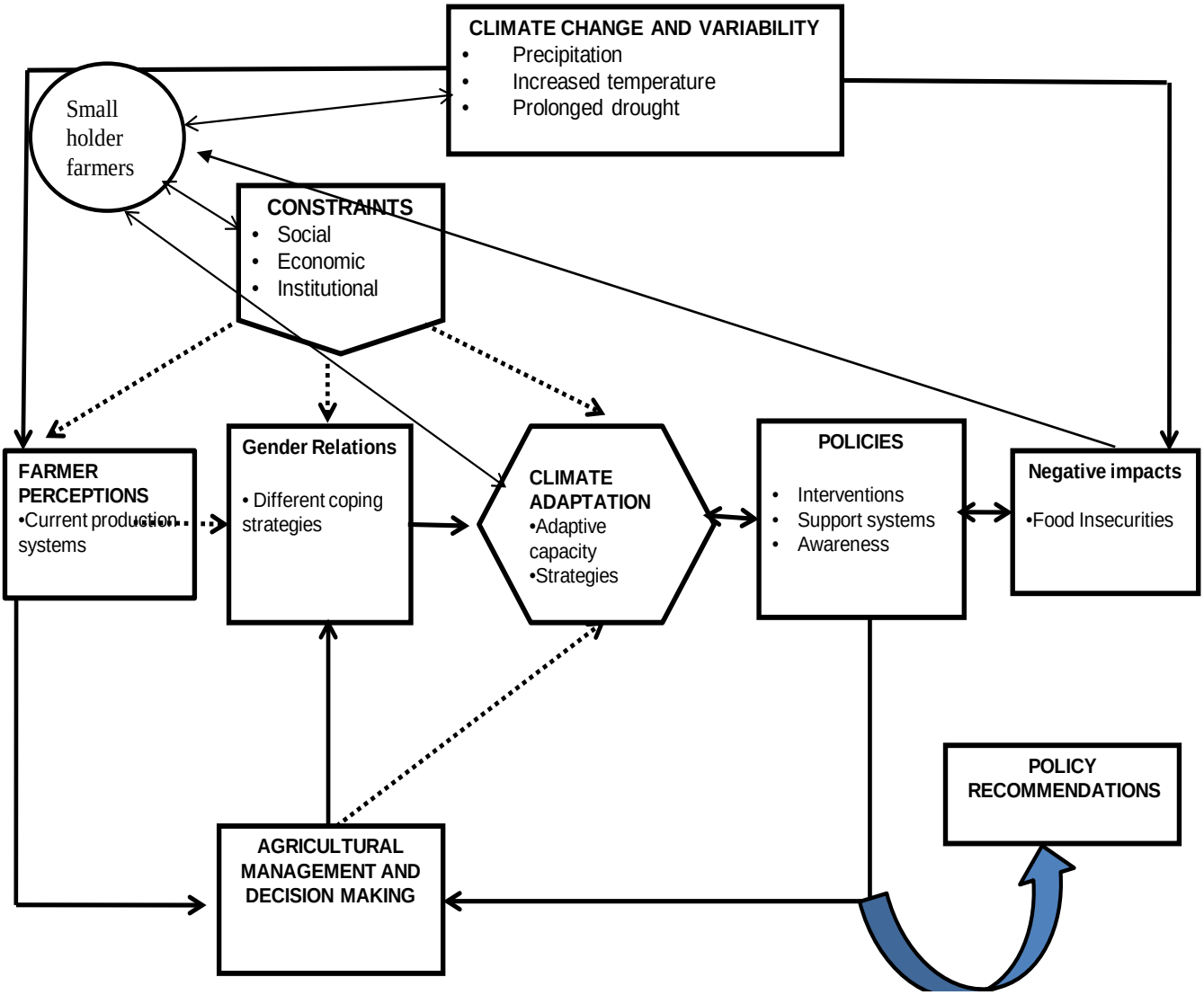

Figure 1: Adapted climatic Framework – (Adapted from Agrawal, 1995)

Figure 1 describes the link between climate change and variability on smallholder farmers, socially, economically and institutionally. Climate change and variability negatively affect the production system of smallholder farmers. The smallholder farmer attempts to mitigate the impacts of climate change by employing different coping and adaptation strategies which differ among gender. The adaptation capacity and well-being of the farmers is influenced by the availability and accessibility of climate change interventions and support systems as well as access to climate change information (awareness). Lack of support systems during unpredicted precipitation season, increased temperatures and prolonged droughts, results in food insecurity

amongst smallholder farmers. Therefore, for better adaptation towards the impacts of climate change there is a need for the government to put in place policies in a bottom-up approach that will support smallholder farmers adapting to climate change.

2.3 Impact of climate change on smallholder farmers' rural livelihoods

Due to their socio-economic position, smallholder farmers are among the most disadvantaged and vulnerable groups affected by climate change and variability (IFPRI, 2007; ASFG, 2013). Smallholder farmers in the southern African region are set to be most affected by these climate variations due to poor access to information, low access to technology and dependency on climate sensitive agriculture (Morton, 2007; Mutekwa, 2009; Oxfam, 2007). Therefore, the impact of climate change and variability threatens and weakens the already vulnerable smallholder farmers whose main source of livelihood is rain fed agriculture.

In South Africa rural smallholder farmers are vulnerable to climate change and according to FAO (2008), Clark (2012) and Maponya (2013), it is expected to increase food insecurities and worsen the poverty status among rural communities, affecting all four dimensions of food security, which are food availability, accessibility, utilization and stability, as well as livelihood assets. As indicated by Komba and Muchapondwa (2012), smallholder farmers' production systems are directly threatened by the increasing temperatures that cause heat stress on plants, reducing water availability and lowering overall productivity.

The changing climate poses a negative impact on overall productivity; soil fertility due to the very hot temperatures accompanied by dry winds leading to erosion, wilting of plants and poor production (DEDEA, 2013). The EEA (2009) highlighted that soil is very crucial for the provision of nutrients for plant growth, carbon storage as well as the regulation of water cycle. The increase in temperature and changing of precipitation patterns negatively affects soil quality which results in loss of soil organic matter (Soils Matter, 2013). This negatively affects the soil fertility as rising of air temperatures are likely to speed-up the natural decomposition of organic matter and increase the rates of other soil processes (Altieri and Koohafkan, 2008). This degrades soils which are critical for crop production. Majority of smallholder farmers in rural

areas have no or primary level education, therefore it is difficult for them access information on new technologies on soil management (Wanyama *et al*., 2010). These farmers mostly practice mono-cropping, which is disadvantageous as it degrades soils even more (Patterson and Gardener, 2015). Climate change has also impacted on the erratic rainfalls in South Africa and Limpopo is no different to the effects with the current drought the country is facing.

The Limpopo province in South Africa is relatively dry with an annual average rainfall of 400mm (LDA, 2010). The LDA (2010) highlighted that in Limpopo province, drought is a very serious problem as the province is semi-arid area with low and erratic rainfall. The impact of low rainfall in this region has resulted in loss of livestock, shortage of drinking water, low yields and shortage of seeds for subsequent cultivation. The loss of these natural assets among smallholder farmers minimize their ability to cope with the climatic changes, hence they are vulnerable to climate change. The DEA (2010) highlighted that increasing temperatures in South Africa may support expansion of the borders of vector and water borne diseases (e.g. malaria and cholera), and that climate change may also potentially trigger new and emerging infection epidemics and environmental toxins caused by disruptions to human well-being and to agricultural and natural ecosystems. It is for these reasons that the mitigation and adaptation to climate change should be given attention.

Smallholder farmers' adaptation to climate change at a local level faces poor infrastructure as part of the main challenges due to erratic rains causing floods, destroying buildings, eroding roads and bridges (Ngigi, 2009). In various South African rural areas, smallholder farmers are generally found in remote areas, making it difficult to reach because roads are either in poor condition or non-existent. As a result, there is long transportation time with high costs, due to inadequate transport infrastructure. According to Louw *et al*., (2007) transportation of produce to the markets on time is one of the key constraints for smallholder farmers in rural areas. This therefore, results in loss of quality and late delivery to the markets, leading to produce being sold at lower prices or rejected, so, this means a lack of sustainable income for the smallholder farmers, which affects their livelihoods as well as their food security (Baloyi, 2010).

According to Komba and Muchapondwa (2012) smallholder agriculture is the engine of rural economic growth and the main source of most smallholder farmers' livelihoods. IFAD (2010) estimates that there are about 500 million smallholder farms in the world; in Asia and sub-Saharan Africa smallholder farmers produce up to 80% of the food consumed and support up to two billion people. However, global climate change has increased vulnerability leading to poverty and human food insecurity. According to Dinar *et al*., (2008) in South Africa the agricultural sector contributes 3.4% to the Gross Domestic Product (GDP) and employs 30% of the labour force, and for the third quarter of 2010 Primary agriculture contributed about 3% to the GDP of South Africa whose nominal value was estimated at R667 billion (Chamuka, 2011). However, regardless of the great contribution agriculture has to the economy, it could be greatly affected by climate related disasters such as erratic rainfalls, floods and extended dry seasons.

In many parts of Africa, the current climate is already marginal with respect to precipitation and further warming in semi-arid areas is likely to be devastating to agriculture (Dinar *et al*., 2008). Climate may change more rapidly than expected and is projected to have complex, long term effects on the environment. According to Komba and Muchapondwa (2012) climate change brings about substantial losses especially to smallholder farmers whose main source of livelihood is derived from agriculture. Dinar *et al., (*2008) highlighted that yields could fall quite dramatically in the absence of costly adaptation measures. Moreover, Kurukulasuriya and Mendelsohn (2008) stated that the negative impacts of climate change can be significantly reduced through adaptation strategies. Therefore, there is a need for investments to improve agricultural productivity under the risk of climate change (Schlenker and Lobell, 2010).

2.4 Gender relations and climate change

Gender inclusivity and transformation is an important component in addressing climate change; however, it is often overlooked and not given the attention it deserves, excluding or marginalising women who are the providers and who often work the fields to provide food. Studies revealed that climate variability and change affects women much more than men, as women constitute the majority of the world's poor and are more dependent on natural resources for their livelihood that are threatened by climate change (Babura, 2013; Dankelman, 2011; Teklewold, 2013). According to the UNAIDS (2009) in many countries women are said to bear

the burden of climate change simply because they are said to dominate the agricultural sector and lack control over their lives and access to as many opportunities as men to generate income. Hence, they are more affected and more likely to see their poverty status increase. Women are also excluded from decision-making on access to and the use of land and resources critical to their livelihoods.

Women face social, economic and political barriers that limit their coping capacity, this is attributed to the social power and freedoms men have over women, for example, men can migrate as an adaptation method from drought stricken areas, as they are more detached from family responsibility than women (Okali and Naess, 2013; UN, 2009; Benhin , 2008). Another example, women are responsible for water management at the household level, so they are responsible for fetching water for their families and spend significant amounts of time daily carrying water from distant sources and in many cases the water from distant sources is hardly ever enough and is often contaminated to meet the household needs, resulting in women and girls to bear the burden and pay the heaviest price of poor sanitation (UN, 2009). In addition, the FAO (2008) also highlighted that sometimes due to poor health women may not be able to produce enough to feed everyone in the family, therefore, they usually eat last, after the men and the boys, as a result this affects their nutritional status meaning that within a household, women are normally food insecure.

Statistics show that in the developmental context women are key players, as they account for 50% of any country's workforce and talent, greatly increasing productivity while fostering economic growth (Doss, 2011). Women tend to hold and have more knowledge than men, especially in agriculture, due to the traditional role as food providers in the household. However, regardless of their vast knowledge and coping strategies, women's opinions continue to be excluded from participating in policy making/planning concerning the impacts of climate variability and change (Nellemann, 2011). Literature highlights that agricultural programs reveal that when women are with equal resources, they produce yields that are equal to men if not surpassing them (Teklewold 2013; Okali and Naess, 2013; Doss, 2012). In addition, women are more likely to impart knowledge and use their income to improve the well-being of their families and communities at large. All women run a risk of being victims of climate change issues

nevertheless; those in developing and least developing regions of the world are particularly more vulnerable due to their high dependency on utilizing local natural resources (Quan, 2011). The lack of skills and illiteracy seen in women widens gender gaps in earning and all forms of economic activity; women make 30-80% less of men's annual income (FAO *et al.*, 2012; Nellemann 2011; World Bank 2011).

2.5 Smallholders perceptions on climate change

Smallholder farmers' adaptation decisions are guided by their perception to climate change and variability, and climate related risks. The vulnerability, resilience, coping and adaptive capacity of farmers to climate change and variability in semi-arid systems could be addressed through different adaptation strategies. Smallholder farmers need to be able to identify the changes already taking place in their areas and institute appropriate coping and adaptation strategies. A farmer's ability to perceive climate is a pre-requisite for their choice to cope and adapt (Moyo *et al.*, 2012; Kihupi *et al*., 2015). The coping and adaptation strategies of smallholder farmers depend, to a large extent, on their perception knowledge level on climate change (Kihupi *et al.*, 2015). In essence, adaptation to climate change and variability requires farmers to first notice that the climate has changed, and then need to identify and implement potential useful adaptations (Adger *et al*., 2005).

Consequently, without adaptation, the vulnerability of communal households that depend on agriculture would increase with climate variability and change. However, these smallholder farming communities have coped and adapted to the effects of climate change and variability over the years (Li *et al.*, 2013). This creates the need for understanding the perception of the smallholder farmers to the impacts of climate change and variability at the local level (Shemdoe, 2011; Kassie *et al.*, 2013).

2.6 Climate change adaptation strategies used by smallholder farmers

According to Deressa *et al.*, (2008) and IPCC (2007), adaptation to climate change can be referred to as change in natural and human systems in response to climatic effects, which moderates harm or exploit beneficial opportunities. Most countries in sub-Saharan Africa are mostly vulnerable to impact of climate change, due to high dependence on agricultural

production and limited adaptive capacity (Bryan *et al*., 2013). The effects of climate change in Africa are practically seen through reduction in the length of growing season which forces large regions of marginal agriculture out of production (Boko *et al*., 2007). Mutekwa (2009) revealed that climate change studies have been conducted across the globe and they are still uncertain on the frequency and severity of adverse weather events.

Several studies have been conducted around the globe on how smallholder farmers adapt to changing climate and the importance of adapting agriculture to climate change in the continent (Deressa *et al*., 2009; Mertz *et al*., 2009; Hisali *et al*., 2011; Kemausuor *et al*., 2011; Below *et al.,* 2012). All these studies have concluded that most farmers perceive that the climate is changing and are taking up several adaptation measures to reduce the impact. Some of the adaptation strategies used by farmers are identified by Below *et al.,* (2010) who identified about 104 different adaptation practices which are broadly categorized into farm management and technology; farm financial management; diversification of farm and off-farm activities; government interventions in infrastructure, health and risk reduction; and knowledge management, networks and governance (Osbahr *et al.,* 2010). Crop varieties and livelihood diversification are some of the major adaptation measures adopted by farmers throughout the continent; however, the choice of the adaptation options is influenced by different contextual factors (Gbetibouo *et al.,* 2010; Hisali *et al.,* 2011; Below *et al.,* 2012).

Other adaptation measures include planting different varieties of the same crop, mixed cropping, water conservation practices and changing from farming to non-farming activities when it is difficult to work on the farm due to intense heat (Gbetibouo *et al.,* 2010). Some of the farmers switched to crops such as cowpea that can tolerate hot weather conditions. A look at the adaptation methods used by the farmers suggests that measures that are relatively inexpensive such as changing planting dates and diversifying crops could be used, while those that are costly or require more capital such as irrigation systems are used by very few farmers (Below *et al.,* 2012). Therefore, this means that the choice of adaptation option is influenced by farmers' financial capabilities. Moreover, this is similar to what Turpie and Visser (2013) have mentioned that crop diversification and changing planting and harvesting dates are potential strategies to adapt to climate change.

However, IFAD (2010) emphasises that adaptation alone cannot avoid all climate change impacts, a focus on awareness of climate change and adaptation in order to support local communities in dealing with the impacts of climate change is needed to respond to this threat. Currently, there are very few development strategies promoting sustainable agriculture. According to Osbahr *et al.*, (2010) successful adaptive actions are those that promote system resilience and legitimate institutional change, and sustain collective action. Below *et al.*, (2010) and Osbahr *et al.*, (2010) further argue that external interventions aimed at facilitating adaptation within communities should further complement the farmers' individual response to climate change, including the development of new drought-resistant varieties, improved weather forecasts, the provision of financial services, mixed farming strategies and improvement of rural transportation Osbahr *et al.*, (2010).

2.6.1 Climate change interventions and support systems for smallholder farmers in South Africa

Climate change scientists, governments and international organisations are advocating adaptation as a more sustainable response to the effects of climate change. There is urgent need to move towards climate-smart agriculture which can be achieved through creating and enabling policy environment for adaptation (Policy Brief, 2013). Literature on climate change argues that with adaptation, farmers' vulnerability can be significantly reduced through adaptation (Kurukulasuriya and Rosenthal, 2003; Odekunle *et al.*, 2007; Gbetibouo, 2009). As earlier indicated, adaptation is the process of recognizing the effects of climate change and adapting to these changed conditions. Adaptation cannot be treated as an isolated event divorced from other policy and institutional imperatives (Chikozho, 2010). In addition adaptation strategies to climate change effects should not only be a top-down approach, rather bottom-up approaches in decision making and implementation should be used. This is strengthened by the International Institute for Environment and Development (IIED) report (2013) which advocates for greater involvement of civil society as well as effective public participation in developing national policy. Matarira *et al.*, (2004) note that without policies or adaptive strategies in place, smallholder farmers will find it extremely difficult to cope in an environment with changed climatic conditions. Policy Brief (2013), suggests the urgent need for support of the country's' implementation of adaptation

measures that enhance agriculture and farmers 'resilience for increased food security. This can be achieved through effective use of indigenous knowledge and maximum stakeholder engagement in decision making processes.

2.7 Proposed climate change interventions for smallholder farmers in South Africa

In South Africa, interventions for smallholder farmers have not been much of a success, because a Top-down approach has been used by the government to address smallholder farmers' challenges, while in this approach people at the top decide on interventions they think might work for the smallholder farmer even though they are not fully aware on how smallholder farmers in rural areas are really affected by climate change and what they really need to adapt. Government in some instances conceptualise interventions they think might work for the farmers without understanding issues affecting them. Therefore, a participatory approach that includes smallholder farmers in decision/ policy making is important. A Bottom-up approach could be most effective, because farmers will be more involved and they will highlight the main challenges they are facing.

Therefore, climate change issues are not problems that should be dealt with individually. The problems smallholder farmers face are common problems, as a result, the government needs to put in place policies that will work in favour of smallholder farmers adapting to climate change with the help of extension officers. Follow up on whether these proposed interventions are actually being implemented and the farmers are getting the help that they need, through investing in agricultural research as well.

2.8 Summary

In most rural communities, agriculture is the back-bone and the primary source of people's livelihoods. It is important for food security as it produces the food people eat. However, it is the most vulnerable and affected sector by climate change putting the livelihoods of rural poor at risk and vulnerable to food insecurities. Climate change and variability affects agricultural performances and productivity through droughts, floods, pests and diseases affecting crops and livestock, germs and contaminated drinking water. These effects are greatly experienced by most smallholder farmers in rural areas. They are the most vulnerable group due to the fact that they

have high dependency on climatic sensitive resources which are rain-fed. However, some farmers are moving towards adaptation by changing their planting dates, intercropping and diversifying, but some smallholder farmers are slower to adapted due to the general lack of knowledge, expertise and data on climate change issues; a lack of specific climate change institutions to take on climate change work and the need for a better institutional framework in which to implement adaptation.

Chapter 3: Methodology and Description of the Study Area

3.1 Introduction

This chapter outlines background information regarding the study area and research methodology used in the study. An overview of the livelihood activities of Mopani and Vhembe districts are highlighted. Included in this chapter are the study conceptual framework, sampling technique, data collection and data analysis techniques.

3.2 Study Conceptual Framework

The conceptual framework of the study presented in Figure 3.1 shows the linkages of climate change effects on smallholder farmers' food security and nutrition status as well as their well-being. Climate change effect causes a decline on agricultural productivity due to extreme weather conditions experienced. The decline in crop production results in limited food availability for smallholder farmers. This leads to substitution with undesirable commodities, negatively affecting the nutrition security of smallholder farmers, as well as minimizing their livelihood options. Therefore, to avoid smallholder farmers' vulnerability due to climate change, climate change interventions and support systems should be available, accessible and useful to the smallholder farmers. Agricultural production would significantly contribute towards an improved food security and nutrition status and maximised livelihood options for improved well-being of smallholder farmers'.

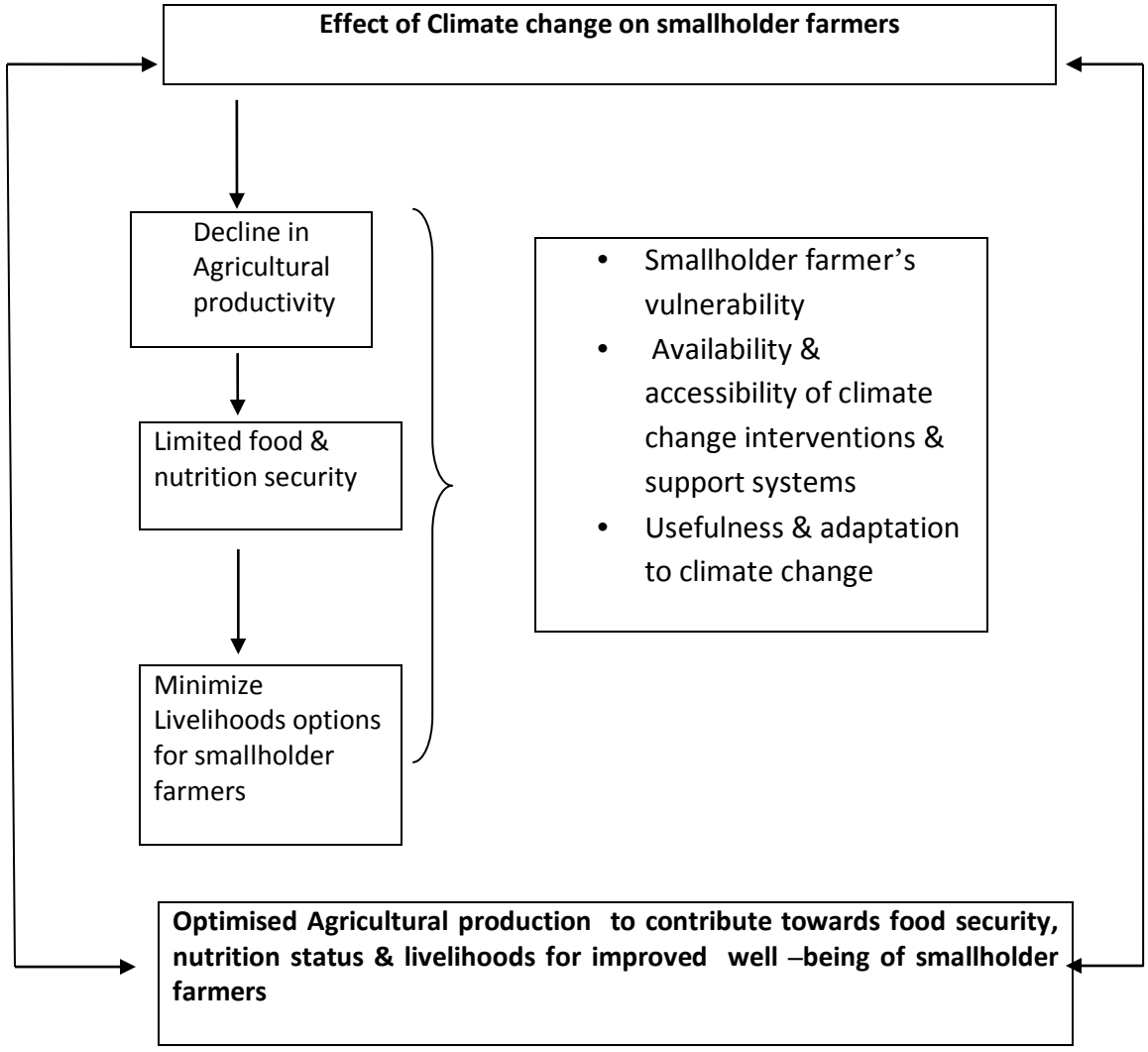

Figure 2: Study Conceptual framework

3.3 Description of the study area

The study was carried out in Limpopo province (Figure 3) which is the fifth largest province amongst South Africa's nine provinces (South African Government, 2013). Limpopo province is the northern province of South Africa which has a huge unspoiled natural countryside that is referred to as the "Golden horseshoe" (Spierenburg *et al.*, 2006). This province is made up of five (5) districts, namely: Greater Sekhukhune, Mopani, Capricorn, Waterberg and Vhembe (LDA, 2012). However, this study focused on the Mopani and Vhembe districts. As reported in

LDA (2012) these districts are regarded as the most affected districts by climate change in Limpopo.

The entire province covers an area of 12, 46 million hectares, which is 10, 2 % of the total area of South Africa (Oni *et al.,* 2012). This province has three distinct climatic regions that can be classified which include the Lowveld (arid and semi-arid) regions, the middle veld, highveld, semi-arid region and the escarpment region which have sub-humid climate with a 700mm rainfall per annum (LDA, 2012). The climatic variation experienced in Limpopo allows this province to produce a variety of agricultural produce such as tropical fruits, cereal and vegetables. Therefore, agriculture in Limpopo province is seen as a cornerstone of the province's economy. However, there are two types of agricultural production systems taking place in Limpopo province, as a result of past apartheid regime policies (Oni *et al.,* 2012). The two distinct agricultural production systems are the large scale commercial farming system and the smallholder farming system.

The large scale commercial farming system in the province is mainly dominated by the white population of South Africa who has the most advance production technologies, and well organized farms situated on prime land which covers about 70% of the total land area. Currently, there are about 5000 commercial farming units in Limpopo province (Statistics South Africa, 2009). On the other hand, smallholder farmers are located in remote areas with low level of production technology, a farm size of about 1.5 hectares per farmer, covering about 30% of the provincial land. In 1995 Statistics South Africa (1998) estimated that there were about 519 000 smallholder farmers with about 80% being women. However, the estimation has decreased to 273 000 in year 2000. Therefore, this means that currently there are over 273 000 smallholder farmers situated in remote areas with inadequate infrastructure and institutional support in Limpopo province (Oni *et al.,* 2012).

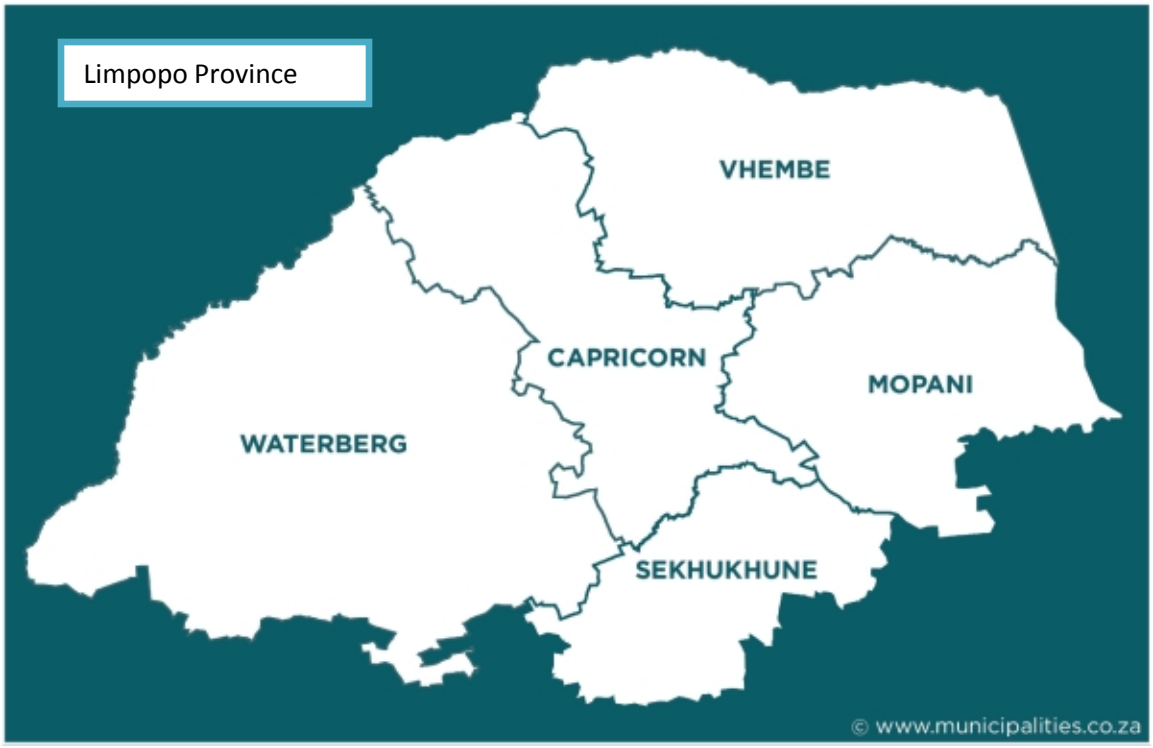

Figure 3: District Municipalities of Limpopo Provincial Map (Limpopo Local Government, 2012).

3.3.1 Mopani District Municipality

The Mopani District (Figure 4) is situated in the North-east part of the Limpopo Province. The district has been named Mopani due to the abundance of nutritional Mopani worm found in the area (IDP, 2012). This district has five local municipalities namely Maruleng, Ba-Phalaborwa, Greater Giyani, Greater Letaba and Greater Tzaneen. However, only two of the five municipalities were studied in this study namely the Greater Tzaneen and the Maruleng local municipality, due to the areas large numbers of smallholder farmers who depend on agriculture for their livelihoods and the high temperature variations experienced. The Mopani district covers an area of about 20 011 km^2 in Limpopo province with a population size of about 1, 092,507 people and 296,320 households (Census, 2011). The district is made up of 14 urban areas (towns and townships), 352 villages (rural settlements) constituting of a great proportion of unemployment and poor people (81%) and a total of 118 wards (IDP, 2012). Farming is the second largest employer in Mopani district with about 25.9% of the employed people. However, this district is characterized by low rainfall (400mm to 900mm), resulting in limited water

resources causing severe water shortages and regular drought conditions particularly in the lower-lying areas of the district.

Figure 4: Map indicating study areas in Mopani District (Limpopo local government handbook, 2012)

Tzaneen Local Municipality

The Greater Tzaneen Local Municipality (23.8333° S, 30.1667° E, Figure 4) was one of the selected study area in Mopani district, this municipality is situated in the eastern quadrant of the province and covers an area of 3240 Km^2 of the 25 344, 13 km^2 total Mopani district (Annual report, 2012). This municipality has a population size of 390 095, with 7.6% of the population practising farming. Greater Tzaneen local municipality is made up of 125 rural villages, in which about 80% of the households residing in these villages are characterised by extensive and intensive farming, 34 wards and 5 urban areas (IDP, 2012). About 62.4% of the population is aged between 15 and 64 years, 48.5% of the population is unemployed youth aged between 15 to

34 years, with 18.7% of the population never attend school, only 21.8% matriculated and 8.7% with higher education (LDA, 2012).

Maruleng Local Municipality

Maruleng Municipality (24.3542° S, 30.9472° E, Figure 4) was the second municipality studied in Mopane district, it is situated in the south-eastern quadrant of the Limpopo Province, covering 3 247 km² with a population size of 94 857 within the Mopani District (Stats SA, 2011). Maruleng encompasses of 12 wards, 31 villages and 1 urban area (IDP, 2012). Agriculture is a key economic sector in this municipality. However, it is characterized by low rainfall resulting in water shortages and drought conditions, therefore crops grown in this area rely on irrigation system available (IDP, 2012).

3.3.2 Vhembe District

Vhembe district (Figure 5) is located in a semi-arid area that is frequently experience dry spells, often growing into severe drought (Mpandeli and Maponya, 2013). The district is the most northern district of Limpopo province with a rainfall pattern ranging between 246mm to 681mm per annum (IDP, 2012). Vhembe comprises of variable soil type, which are sandy in the west and higher loam and clay content toward east. This soil types are mainly developed on basalt, sandstone and biotite gneiss, with low inherent soil fertility (Odhiambo and Magandini, 2008). This district has four local municipalities namely; Musina, Mutale, Thulamela and Makhado. However, only two of the four municipalities were studied in this study namely Musina, Mutale local municipalities. Vhembe district covers an area of about 25 592 km^2 which is predominantly rural, with a population size of about 1, 294,722 people (Census, 2011). Smallholder farms in this district are located mostly in the former homeland areas and their farming is characterized by low level of production.

Figure 5: Map indicating study areas in Vhembe District (Limpopo local government handbook, 2012)

Mutale Local Municipality

Mutale Municipality (22.5833° S, 30.6667° E, figure 5) covers an area of about 2 367.19 km² within the Vhembe District. This municipality is situated in the far north eastern corner of the District, with a population size of about Population 91, 870 people (Census, 2011). There are about 13 wards in Mutale and a high percentage of the rural population is mainly dominated by women between the ages of 15-65 years. The Mutale Local Municipality is prone to frequent droughts and is predominantly semi-arid. Mutale has a dry climate with the majority of the land receiving annual rains of between 300mm and 400mm (IDP, 2014). The Municipality has a moderately limited supply of both ground and surface water. The few catchments in this area are therefore stressed by high demand of water for development activities such as agriculture, human consumption and mining (IDP, 2014).

Musina Local Municipality

Musina Local Municipality (22.4167° S, 29.7500° E, figure 5 is located in the very Northern part of Limpopo Province. This municipality covers an area of about 7 577 km² with 6 wards and a population size of 68 359 (Census 2012). Out of all the 6 wards, ward 2 is regarded as the biggest ward in terms of its population size which is predominantly the farming community. A great proportion of land in the municipality is used for agricultural purposes ranging from cattle farming, arable farming and game farming, and the urban settlements only constitute up to 0.08% of land cover.

3.4 Methodology

Integrated approaches employing both qualitative and quantitative methods were used to collect data on smallholder farmers' perceptions and adaptation strategies towards climate change interventions and support systems. Qualitative research was used to seek understanding on the perspective or situation by looking at first-hand experience to provide data that is meaningful (Tewksbury, 2009). Qualitative data was collected through focus group discussions with smallholder farmers to probe farmer's awareness and understanding of the climate change interventions and support systems; how do they perceive these interventions and if they find them useful. In this study the focus group discussions provided the researcher to further explore the issues that could not be easily unpacked or explained through the questionnaires.

The quantitative research method mainly uses numerical analysis to reduce data into numbers or percentages unlike qualitative method. This method uses close-ended questions. In this study the quantitative method was used to compare responses across the participants because all participants were asked identical questions in the same order to allow for significant comparison of responses across participants and study sites (Crossman, 2014). The questionnaires were administered by individual farmers to provide information on their perceptions towards climate change support systems available to them to cope with the climatic and none-climatic challenges, their observations on the major changes in weather they have observed in their community over the last 10 years, adaptation measures they have used to deal with changes in temperatures, crops they cultivating and what influences their decision as well as their sources for crop irrigation.

3.5 Sampling Technique

The population participated in this study were smallholder famers residing in two districts Municipalities in Limpopo province namely the Mopani and Vhembe. These two districts were selected based on the fact that smallholder farmers in those districts for a very long time have been experiencing extreme climatic risk as well as high climate variability (Census, 2012). According to Mpandeli (2014) the majority of Vhembe smallholder farmers are vulnerable to all types of climatic risk, because they have low education level making it difficult for them to access technology, they lack financial resources, they have a low level of resilience resulting in low adaptive capacity.

3.5.1 Study area selection

In each district two local municipalities were further selected, the Greater Tzaneen local municipality and Maruleng local municipality under the Mopani district, because in these two municipalities majority of smallholder farmers are characterised by both extensive and intensive farming and they mostly depend on rain-fed irrigation. The Mutale and Musina Municipalities within the Vhembe district were selected as study areas due to the fact that within those municipalities a great proportion of land is used for agricultural purposes and smallholder farmers are experiencing dry climate with the majority of the land receiving annual rains of between 300mm and 400mm.

3.5.2 Population sampling technique

A purposive random sample of 150 smallholder farmers participated in this study. About 40 participants were targeted from each municipality. A criterion to select the participating sample was set as follows: the respondents were individual smallholder farmers, practicing crop production, producing for subsistence and the surplus for sale, with high level of dependency on rainfall for irrigation and land size ranging between 1 to 5 hectares. The local extension officer of each local municipality provided a list fitting the stated criteria and 35-40 smallholder farmers were randomly selected from each local municipality. A group between 9-14 participants from the survey volunteered to participate in the focus group discussions. From each municipality 5 key informants including the extension officers also participated in the transect walks.

3.6 Data collection tools

3.6.1 Transect walk

Transact walk was used as a data collection tool to interview the farmers about their farming practices, adaptation and coping strategies. In each local municipality a transact walk was conducted with a small group of farmers (maximum 5) to observe the perceived climate changes, the use or none-use of climate change interventions and coping strategies. The farmers were mainly leaders and those who have been farming for a longer period of time who could share their farming experiences and provide critical perspectives towards climate interventions and support systems.

3.6.2 Survey

Questionnaires are tools used for collecting data in a survey research; this tool included a set of standardized questions. In this study, questionnaires were used to collect information about demographics, awareness, perceptions, experiences and assessment of usefulness of the climate change intervention and support systems. This tool also was used to explore agricultural production and smallholder farmers' adaptation strategies towards climatic and non-climatic shocks, in form of an interview. Questionnaires were administered to individual farmers by the research team.

3.6.3 Focus group discussions

According to Onwuegbuzie *et al.,* (2009) focus group discussions are used to collect in-depth qualitative information about groups' perceptions, attitudes and experience on a defined topic. Therefore, in this study focus group discussions were used to collect in-depth information on smallholder farmers' perceptions towards climate change support systems, interventions and experiences towards climate change. Two focus group discussions from each local municipality were conducted.

A trained facilitator conducted the focus group discussions. A recorder and video were used to document the sessions. Oral and written consent were requested from the participants before the beginning of each session. Furthermore, a Venn diagram within the focus group discussions was used to explore power issues and relationships between smallholder farmers and the climate

support system providers available to them (appendix C). A SWOT (Strength, Weakness, Opportunities and Threats) analysis was also done to determine whether the climate interventions and support systems were of use to the farmers and to create a scenario of how they could be effective and efficient to their situation. Towards the end of each session the facilitator provided a summary of the discussion and the participants were asked to verify if the information was correct.

3.7 Data analysis

A Statistical Package for Social Sciences (SPSS) version 23.0 was used for data analysis. Data collected was manually coded and analyzed using descriptive statistics and frequencies. Microsoft excel 2010 statistical package and STATA version 8 statistical package were also used to analyze the data. Frequencies were done in order to investigate and present climatic and non-climatic shocks faced by smallholder farmers, their adaptation strategies and their informers. Focus group discussions were analyzed through content analysis by identifying themes, concept, patterns and trends. Multinomial logit regression model was used to analyse the factors influencing the choice of climate change adaptation strategies by smallholder farmers.

3.8 Summary

This chapter provided a description of the methodology applied in this study. The focus was mainly on the research topic: Smallholder farmers' perceptions and adaptation towards climate change interventions and support systems in Limpopo province, South Africa. Data was collected in four municipalities (Tzaneen, Maruleng, Musina and Mutale) from two districts (Mopani and Vhembe districts). Data collection was mainly based on smallholder farmers' responses, and was conducted in the form of focus group discussions, survey questionnaires and transect walk, with the aim to do a comparison of farmers responses. In this study focus group discussions and transect walks with farmers verified each other and were used as participatory tools to provide insight into how useful did farmers perceive the climate change interventions and support systems. These tools provided an opportunity for the researcher to uncover sensitive and nuanced information that could not be gleaned so easily using survey-based methods. Through the use of Venn diagrams the researcher managed to unveil additional information about the power and relationship issues between farmers and the institutions/organisations that provide climate change related information, interventions and support systems. The combination

use of these tools presented a rich picture and information on usefulness of climate change interventions and support systems from the farmer's perspective.

Chapter 4: Smallholder farmers' perceptions towards the availability, accessibility and usefulness of climate change interventions and support systems in Limpopo province

4.1 Abstract

Climate change is rapidly emerging as a global critical development issue affecting many sectors in the world. The effects of climate change are already felt greatly by smallholder farmers in rural locations as they are experiencing crop failure, decline in yields, lose of assets and livelihood opportunities. The study investigated the perceptions, toward the availability, accessibility and usefulness of climate change interventions amongst smallholder farmers. Hundred and fifty questionnaires were administered to smallholder farmers who were subsistence farmers who produced for household consumption and sale, which was seldom; those who were farming for both household consumption and selling the surplus; and those who were mainly selling referred to as '*food producers'* because their primary goal was to produce for the market. The questionnaires were complemented by 8 focus group discussions withdrawn from the survey for further probing. Transect walks were also conducted to triangulate the above mentioned tools. The study findings highlighted that crop production was regarded as a way of life especially amongst women farmers (64%). The climate change effects have been experienced through decline of productivity compromising food security and livelihood options as 73% famers sold surplus who depend on the income generated from sale. About 67% of the farmers were not aware of climate change interventions and any climate change support systems. Consequently, 78% farmers relied more on their indigenous knowledge for adaptation to climate change and variability. Both indigenous knowledge and radio were regarded as available and accessible based on trust, convenience, cost effectiveness and reliability to provide climate change information and support for subsistence farmers and those who were farming for both household consumption and selling the surplus, on the other hand, *food producers* preferred extension officers and NGOs for provision of support services. Therefore, there is a need to consider integration of indigenous knowledge system-based climate change support and interventions with scientifically derived information to empower subsistence farmers with adequate adaptive capacity to better respond to climatic challenges, as well as training of extension officers regarding climate change.

Keywords: Smallholder farmers, climate change, awareness, availability, accessibility, intervention, support systems, usefulness, food producers.

4.2 Introduction

Climate change is rapidly emerging as a global critical development issue affecting many sectors in the world, and is considered to be serious threats to sustainable development. Globally, an unprecedented increase in greenhouse emissions has led to increased climate change impacts threatening agriculture and food security. Since 1805 the world has been experiencing temperature increase, leading to variability in rainfall and temperatures, directly affecting agriculture (FAO, 2008). The rising temperatures are expected to cause decline in agricultural production, threaten biodiversity, productivity of natural resources, and increase the range of vector-borne and waterborne diseases (Abukakari and Abubakari, 2015). These changes in climate have led to serious impacts on the four dimensions of food security: food availability, food accessibility, food utilization and food system stability (UN, 2009). The effects of climate change are already felt greatly by smallholder farmers in rural locations since they are experiencing crop failure, decline in yields, lose of assets and livelihood opportunities, endangered health, and having difficulty to cope due to their high dependency on agriculture, local and natural resources for their livelihoods (Cherotich *et al*., 2012). In African countries most smallholder farmers practice crop farming at a subsistence level and it is rain-fed dependent. The frequent changes in climate and erratic rain affect farmers' production systems. This makes Africa particularly vulnerable to the impacts of climate change (Dougill, 2009). The vulnerability of the region is further worsened by resource constraints to counter the effects of climate change and vulnerability.

In sub-Saharan Africa, climate change is set to affect the agricultural sector severely and cause suffering, particularly for smallholder farmers (Turpie and Visser, 2013; Hassan *et al*., 2008; Deressa, 2006). There is growing interest in the likely impacts of climate change on agriculture, economic growth and sustainable development. According to Ozor and Nnaji (2011), sub-Saharan Africa has been experiencing increased drought in recent times due to increased temperature and reduced rainfall. The noticed incidences of climate change include changes in soil moisture, soil quality, crop resilience, timing/length of growing seasons, decline in crop yield, flooding, and unprecedented droughts.

South Africa is no different from other countries as climate change is threatening the food security agenda of the country (HSRC, 2014). Climate change has been viewed as worsening poverty status among the rural population. It presents major threats in achieving the New Sustainable Development Goals which were built on the Millennium Development goals, due to its adverse impacts which undermines all countries capability to achieve sustainable development (UNDP, 2015). The SDGs aim to encourage development by improving social and economic conditions, eliminating poverty and hunger, and promoting environmental sustainability (UN, 2015). In many studies, awareness of climate change to smallholder farmers has been of great concern and climate change adaptation measures have often been encouraged in many African countries, in order to reduce the negative effects of climate change (Mandleni and Anim, 2010). However, according to Fischer *et al.*, (2005), developing countries are more vulnerable to climate change than developed countries due to high dependence on rain fed agriculture in their economies and scarcity of resources such as capital, accessibility and availability of information and inputs for adaptation measures. The UNDP (2011) highlighted

that one of the key challenges to the development of detailed climate change predictions in Africa is the lack of climate information and its accessibility.

Most studies have been conducted on the negative impacts of climate change on rural smallholder farmers, and it has been an area of concern to global agencies as they believe that rural smallholder farmers may not be adequately empowered to respond and adapt to the future magnitude of changes in climate (Cherotich *et al*., 2012). Thus, the availability and accessibility of climate support services play an important role in disseminating by Early Warning Systems (EAS) as well as increasing alertness and disaster preparedness to a changing climate (Cherotich *et al*., 2012; Mandleni and Anim, 2010). In South Africa numerous studies have been conducted on climate change and its impacts on rural livelihoods (Dougill, 2009; Mandleni and Anim, 2010; Maponya and Mpandeli, 2012).However, there is still a barrier for smallholder farmers to access climate change information.

In Limpopo province, agriculture is a cornerstone of the economy as it supports the livelihoods of most rural households. The smallholder farmers referred to as 'small-scale food producers' are regarded as the drivers of rural economic development (LDA, 2012). However, these farmers have been reported to be highly dependent on the climate sensitive natural resources increasing their vulnerability to climate changes. As suggested by Cherotich *et al.,* (2012), climate change interventions and support services provide an opportunity for the farmers to withstand the climatic challenges thus strengthen their agricultural productivity. Although many studies have been conducted to investigate the negative impacts of climate change on rural smallholder farmers and their adaptation strategies, there seems to be little information on whether the climate changes interventions and support systems are available and accessible to the farmers. This study, therefore, aims to investigate the availability and accessibility of climate change

interventions and support systems to smallholder farmers' in Limpopo province. It is argued that availability and accessibility of these interventions and support would increase the preparedness of the farmers and provide them with sufficient levels of information to reduce vulnerability to climatic challenges for improved food security and livelihood options.

4.3 Materials and Methods

4.3.1 Description of the study area

The study was carried out in Limpopo province within two district municipalities namely Mopani and Vhembe. The Mopani District is situated in the North-eastern part of the Limpopo Province covering an area of about 25 344, 13 km^2 in the province, with farming as the second largest employer in the district. However, this district is characterized by low rainfall between 400mm to 900, resulting in limited water resources causing severe water shortages and regular drought conditions particularly in the lower-lying areas of the district. Vhembe district is located in a semi-arid area that is frequently affected by dry spells, often leading to severe drought. The district is the most northern district of Limpopo province with an average annual rainfall ranging between 246mm to 681mm in Musina and Mutale respectively (see chapter 3 for detailed description of each district municipality).

4.3.2 Methodology

Both qualitative and quantitative methods were used to collect data in the study. The quantitative research method was used to compare responses across the participants since they were asked identical questions in the same order to allow for significant comparison of responses across participants. On the other hand, the qualitative research method was used to seek understanding of the farmer's perspective or situation by regarding the participants as experts of their situation. This methodology was found appropriate for this study because the study aimed to find

meaningful answers and experiences of farmers with regards to the availability and accessibility of climate change interventions and support systems.

4.3.3 Research design and sampling technique

A representative population of 150 smallholder farmers in Mopani and Vhembe participated in this study. As reported in the LDA (2012) the two district municipalities were the most vulnerable to climate change experiencing extreme climatic risk as well as high climate variability. A purposive random sample of 150 smallholder farmers were selected using the following criteria: *individual smallholder farmers, practicing in crop production, producing for subsistence and surplus sold, they have high level of dependency on rainfall for irrigation, with a land size ranging between 1 to 5 hectares.* The local extension officer of each local municipality provided a list fitting the stated criteria and the farmers were randomly selected from each local municipality.

The focus group discussion participants (between 9 and 14 per session) were also selected using the same criteria. Two focus group discussions from each local municipality were conducted. A trained facilitator conducted the focus group discussions. A recorder and video were used to document each session. Ranking, Venn diagrams and SWOT (strength, weakness, opportunities and threats) analysis were used to elaborate on dynamic issues and experiences around the climate interventions and support systems.

With regards to the transect walks, a small group of 5 farmers who fitted the criteria but did not participate in the focus group discussions were selected in 4 local municipalities. The key informant interviews (3 per municipality) were also conducted with the extension officers

referred to as ‘agricultural advisors’ and the leaders of farmers’ organizations to verify certain information.

4.4 Validity and trustworthiness

The questionnaire was pre-tested with a small group of smallholder farmers around the study areas however; they did not participate in the study. This was done to ensure that the translation from English to siPedi was accurate and to identify ambiguous questions. Enumerators were trained to understand the questions and to probe for additional information where necessary. Furthermore, the focus group discussions were conducted by a trained facilitator who spoke the local language. Towards the end of each session the facilitator provided a summary of the discussion and the participants were asked to verify the information collected. More so, the transect walks, key informant interviews, focus group discussions and the survey tools were employed for validation of data through cross verification from two or more sources (see Appendix A, B and C).

4.5 Ethical considerations

Permission was granted by the Provincial Limpopo Department of Agriculture, the local municipalities and the extension officers provided authorisation. The smallholder farmers provided oral and written consents before the beginning of each session (see Appendix D). The study findings and recommendations will be present back to the communities in completion of the study.

4.6 Data analysis

A Statistical Package for Social Sciences (SPSS) version 23.0 was used to capture data. Data collected was coded and analysed using descriptive statistics. The coded demographic data

provided a general overview of who is mostly involved in farming, the age group that is most active as well as information with regards to the heads of households. Frequencies were done in order to investigate smallholder farmers' awareness, availability and accessibility of climate change interventions and support systems. Focus group discussions, transact walks and key informants interviews were analysed through content analysis by identifying themes, concept, patterns and trends.

4.7 Results and discussion

4.7.1 The demographic characteristics of the Limpopo small-scale food producers

The findings confirm the stereotype denoting agriculture as an activity for women, due to their perceived roles as custodians of families while men are usually involved in other cash-based activities to secure the livelihoods. Table 1 shows that the majority of individuals involved in rural agriculture were women (64%), compared to 36% men. Another trend verified in this study was that the most active age group in farming were elderly respondents between the ages of 50-69 (70%) of the total sample, with only 1% of the age group 30-39 years. This showed that older people were more involved in farming than youths. As a result of these phenomena one can denote that agricultural knowledge could be disappear as the older generation are the custodians of information. For future interventions and planning in agriculture youth should be considered. It was further established that farming was a coping strategy for most of the people with low education as 54.7% of the farmers had no formal education and only 2.7% had attended tertiary education. This indicates a high proportion of illiteracy amongst the farmers (Table 1)

Table 1: Respondents demographic profile

Variable description	Categories	Frequency	Percent (%)
Gender	Male Female	54 96	36 64
Age	30-39 40-49 50-59 60-69 70-79 80-89	2 19 43 62 2 3	1.3 12.7 28.7 41.3 14 2
Level of education	No formal education Primary Secondary Tertiary	82 35 29 4	54.7 23.3 19.3 2.7
Household income (ZAR/month)	Below 800 800-1500 1500-3500 Above 3500	25 89 22 14	16.7 59.3 14.7 9.3
Source of Income	Pension Farming Part-time job Remittances Social grant	58 73 5 1 13	38.7 48.7 3.3 0.7 8.7

n=150

Agriculture served as a buffering system as the majority of the respondents were receiving their income from farming (48.7%) hence crop production was regarded as a way of life by the farmers. These findings confirm the LDA (2012) report that agriculture in Limpopo is viewed as a cornerstone of the rural economy because most farmers generate their livelihoods from it.In this study, agriculture was the main diversification strategy used by the farmers to complement their household income. As reported in Table 1, 59.3% of the respondents received between ZAR801 to ZAR1500 per month, with only 9.3% who were receiving income above ZAR3500

per month from farming and part-time jobs. The findings indicate that agricultural income was the major stabiliser and buffer of the household economic status. As a result for these agriculture dependent vulnerable groups, any exposure to risks and minor changes in climate can have disastrous impacts to their household food security status and poses imbalances in livelihoods.

Description of the production system of the small-scale Food Producers (FPs)

From all four municipalities, the majority of subsistence farmers were located mainly in Tzaneen (23.8333° S, 30.1667° E), Maruleng (24.3542° S, 30.9472° E) and Mutale (22.5833° S, 30.6667° E). These farmers are resource poor; lack farm inputs such as irrigation systems and have limited support from the government and NGOs (non-governmental organization), unlike the '*food producers'*. The subsistence farmers had limited support from extension officers and NGOs, but they mentioned the dedication of extension officers as support systems. Despite the fact that the extension officers were regarded as important, they were viewed as less influential due to limited powers of authority and inadequate knowledge or information at times. On the other hand, the *food producers* shared a different opinion. They had extension officers and NGOs available and accessible to them which attributed to them doing very well on their production, hence they call themselves '*food producers'*. These farmers were mainly from Musina local municipality, Nwanedi village (22.4167° S, 29.7500° E). In Musina, the extension officers also had limited information on climate change, they had NGOs to assist and provide information to farmers for better yield production. The farmers also highlighted the extension officers and NGOs as being very influential on their crop production, and getting much support from them and helping them with market access.

In all the municipalities, 45% of the farmers had land larger than 1ha and less than 2.5ha, 29% larger than 2.5ha which were mostly the *food producers* and 25% had less than 1ha (Table 2).

Table 2: Production systems of the small-scale farmers

	Frequency (n=150)	Percentages (%)
Land Size (ha)		
Less than 1ha	38	25.3
Greater than 1 and less than 2.5ha	68	45.3
Greater than 2.5ha	44	29.3
Water Sources for irrigation		
Rain-fed	108	72
River	29	19.3
Tanks	2	1.3
Rain harvest	5	3.3
Dam	6	4
Crops planted		
Maize	81	54
Tomatoes	17	11.3
Traditional Leafy Vegetables	13	8.7
Ground-nuts	8	5.3
Chillies	6	4
Okra	6	4
Butternut	5	3.3
Spinach	4	2.7
Onion	4	2.7
Cabbage	3	2
Green-beans	3	2

Similar findings were highlighted by Jaeger (2010) where subsistence farmers had access to an average of 2 ha or less of land for their agricultural production. Seventy two percent of the fields were rain-fed, 19.3% used river water, 4% used dams and 3.3% used rain harvest technology. Only 24.3% cultivated the whole area and 10% of the farmers cultivated quarter of the land due to water shortages resulting from prolonged droughts. This situation hindered the optimised production of food in these communities. The situation of prolonged droughts experienced in these communities suggest an opportunity for the farmers to be knowledgeable and informed

about the decisions they make when selecting varieties and their agronomic practices. Maize was the most grown crop (54%) followed by tomatoes (11.3%) and the least being green-beans (2%).The main reason of selecting these crops was for human consumption at a household level. These results highlight the importance for smallholder farmers to have adequate access to climate information. This will mean confidence during crop selection within the farmers and improved crop yield as they would select crops based on its suitability for their environment, its level of demand and its potential to reduce household vulnerability and poverty.

Crop selection

From the four local municipalities crop selection differed among the farmers. The farmers selected their crops based on different reasons and purposes for farming. The level of support received from the extension officers and NGOs as compared to the major reliance to indigenous knowledge was another identified influencing factor. In this study the smallholder farmers were classified into three groups; firstly, subsistence farmers those who produced for household consumption and only sold seldom; secondly, those who were farming for both household consumption and selling the surplus; lastly, those who were referring to themselves as '*food producers* 'because their primary goal was to sell to the market.

Most of the subsistence farmers selected crops based on the fact that they utilized them as their staple commodities at a household level. Farmers in Tzaneen, Maruleng and Mutale planted maize mainly because it matures early, they consumed it at a household level, it was easy to manage, also drought and disease resistant (Table 3 and 4).

Table 3: Crop selection for subsistence producers (SPs)

Crops	Human Consumption	Easy market access	Early maturity	Resistance to drought	Resistance to disease	Easy management of the crop	High yield potential
Maize	2	6	1	4	5	3	7
Tomatoes	1	4	3	7	6	5	2
Morogo	1	7	4	2	3	5	6
Ground-nuts	3	5	4	7	6	2	1
Chillies	5	4	1	6	7	2	3
Okra	1	5	4	5	6	2	3
Butternut	1	7	4	2	3	5	6
Spinach	1	4	2	5	7	5	3
Onion	2	5	1	7	6	3	4
Cabbage	1	3	2	6	7	5	4
Green-beans	1	5	2	6	7	4	3

Key reasons for crop selection (1 to 7 rated according to the most influential reason)

From 1= main reason to 7 = least influential

The subsistence producers (SPs) and those who were farming for both household consumption and selling the surplus shared similar trends; their decisions were mainly influenced by their Indigenous Knowledge Systems (IKS), this was highlighted during the focus group discussions. Most of their crops were planted because they were preferred for household consumption, as highlighted in Table 3 drought resistance and resistance to diseases were mainly disregarded as the important factor for selection. The HSRC (2015) highlighted that in most cases smallholder farmers in rural area solely depend on IKS because they lack modern inputs, depend on resource-poor agriculture, rely mainly on locally available resources for their livelihoods and have very limited access to climate change information; therefore, it is hard for them to employ new

adaptation strategies without adequate information. The use of IKS by smallholder farmers in rural areas was also observed in Malawi by Kalanda-Joshua (2011) that initially, African farmers have used indigenous knowledge (IK) to understand weather and climate patterns and the decisions they were making about crops and farming practice from it, making IKS the most reliable for the farmers. However, Kalanda-Joshua further argue that the climate variability experienced now have reduced confidence within the farmers indigenous knowledge, minimizing their adaptive capacity.

The *'food producers'* selected their crops mainly for the market. Their crop selection was influenced by crops with high market demand and access, have high yield, mature early and they also consume them (Table 4).

Table 4: Crop selection by Food producers (FPs)

Crops	Human Consumption	Easy market access	Early maturity	Resistance to drought	Resistance to disease	Easy management of the crop	High yield potential
Maize	4	1	3	5	7	6	2
Tomatoes	3	2	4	7	6	5	1
Morogo	6	5	7	2	3	1	4
Ground-nuts	2	1	5	6	7	4	3
Chillies	7	1	4	5	7	3	2
Okra	3	4	1	5	6	7	2
Butternut	4	1	2	6	7	5	3
Spinach	3	2	4	7	6	5	2
Onion	3	1	4	7	6	2	5
Cabbage	5	1	3	6	7	4	2
Green-beans	4	2	3	7	6	5	1

Key reasons for crop selection (1 to 7 rated according to the most influential reason)

The findings of the current study revealed that farmers produced commodities such as maize, tomatoes and traditional leafy vegetables as their staple crops, they have easy market access and they believed that they can withstand the climatic variability. This findings are supported by the Natural Resource Institute (2003), that crop selection for smallholder farmers include crops that are in demand for the market and suitable for the environment.

Planting practices

Although not much was known about climate change and variability interventions, in all the municipalities, 39% of the smallholder farmers were adapting to the increased temperature trends by changing planting dates such as delaying the planting season for some crops, 26% were engaged in crop diversification, 12% were involved in mixed cropping and 23% were not adapting. Similar practices were adopted for the rainfall-37% changed planting dates, 21% crop diversification, 21% intercropping and 3% built water harvesting systems (Table 5).

Table 5: Climate change and variability-based decisions

	Frequency (n=150)	Percentages (%)
Adaptation measure for temperature changes		
Crop and variety diversification	39	26
Changing dates of planting	59	39.3
Mixed cropping	18	12
None	34	22.7
Adaptation measure for rainfall changes		
Crop and variety diversification	32	21.3
Changing dates of planting	56	37.3
Building water harvest scheme	5	3.3
Intercropping	32	21.3
None	25	16.7

Crop Selection		
Indigenous knowledge	64	42.7
Myself	53	35.3
Farmer to farmer advice	18	12
Extension officer's advice	13	8.7
NGO's advice	2	1.3

The FPs highlighted that they receive inputs such as fertilisers provided by the NGOs and extension officers in their fields, however, the subsistence farmers stated that the service was unreliable and offered during the off- season, meaning that extension was less useful to them since waiting for them delayed their production. Hence, in most cases the farmers applied their IKS skills, such as mulching to keep their soils moist for a longer period since there is high demand of water, they used animal manure to keep their soil fertile and they used manual labour to control weed. Kuwornu *et al.*, (2013) further revealed some indigenous adaptation strategies applied by smallholder farmers in Northern Ghana to adapt to climate change and variability included crop diversification, mulching, and change timing of farm operation, change of crops and multiple cropping.

Focus group discussion and field observations during the transect walks highlighted that most farmers in the study areas were practicing monocropping especially the subsistence farmers, as they pointed it out. The farmers believed that this worked for them because these crops are less climatic sensitive and they have a better understanding of managing them. However, Patterson and Gardener (2015) highlighted that monocropping is disadvantageous because planting a similar crop year after year leads to pests and disease outbreaks, and concentrates nutrient uptake from the same soil depth leading to nutrient depletion. This decision by smallholder farmers shows the disadvantage of lacking adequate information for their planting practices; resulting in

wrong decisions with the assumption they are correct. However, this is with an exception for the FPs, as they were practicing intercropping.

Planting patterns

Planting patterns are important adaptation strategy in wake of climate change. The findings have shown that 39.3% of the FPs had changed their planting dates as an adaptation measure to the changes in temperature and rainfall, while 22.7% continued the normal planting seasonal dates, and only 21.3% started intercropping to adapt to the rainfall changes (Table 5): One respondent said that, "*our planting calendar has now changed, we wait for the rain, and so our planting season is now determined by the rain if there is no rain then they don't plant*."Komba and Muchapondwa (2015) also observed that smallholder farmers in Tanzania used similar strategies as Limpopo farmers to adapt to climate change. The farmers addressed the changing climate by changing planting dates, planting drought resistant crops and short-season crops. On the contrary the subsistence farmers used IKS to predict their planting and harvesting seasons by looking at their indicators for rain such as moon shape: "*Since we were young we have been surviving using our own ways of planting, even though we are observing some changes in temperature and rainfall we try to adapt using our own knowledge*." These findings are similar to what Ramanjaneyulu (2012) found in India that due to the changing rainfall patterns farmers use different harvest and planting dates, by trial and error as an adaptation measure. One of the main reasons for subsistence farmers dependence to IKS was attributed to a convenient, logical decision and limited lack of resources rather than ignorance.

The subsistence farmers used their IKS to predict rainy seasons and as an indicator for cropping season, this correlates with Kalanda-Jashua (2011) findings that the farmers in Malawi used

different indicators for predictions mainly atmospheric observations and animal behaviour. These indicators were observed during different times of the year. The moon shape (full moon) and the direction it's facing (North) were used as an indication for planting season; different calls of birds symbolised different weather changes, "black ants" (termites) as they call them, served as an indicator for seasonal weather forecasting as they believed they indicated near rainfall and the colour of clouds was used as a short-term prediction for rainfall (Table 6). Similar findings were observed in Zimbabwe by Jiri *et al.,* (2015) where farmers used their indigenous knowledge systems for long and short term predictions of rainfall; similarly the farmers used tree phenology, animal behavior and atmospheric observations.

Table 6: Indigenous knowledge indicators of weather change in Limpopo

Indicator	Its meaning according to the farmers
Moon shape (full moon)	The direction of the moon (Facing North) symbolized start of planting season
Calls of birds	Different calls were observed for different weather changes in the seasons, high pitch symbolized rain.
Black ants" (termites)	Visibility of too many black ants indicated that it was a rainy season, so they knew they could plant.
Clouds colour	Different colours of clouds could tell if it was going to rain the following day.

During the focus group discussions farmers also mentioned that between 1945-1950 there was a star that used to be seen in the sky which represented rain, and their rain Queen used it to perform rituals and call for the rain, however it is no longer visible: "*We don't see it anymore, so that is when we started to notice climate change effects."* Farmers also highlighted that they observed severe droughts in 1965; the whole community together with their chiefs gathered and

went to the river which was dry and started to pray for rain. Their ancestors/God then answered their prayers because it rained heavily that season: *"Chiefs used to have powers to also call for rain, but now the powers have been taken away because rituals are not being observed, so our ancestors might be punishing us"*. These results show how important and useful social capital is within rural communities. However the priorities have now shifted. Rural communities from Nigeria and Zimbabwe were also said to have used their IKS to predict weather systems such as rainfall and they make use of their IKS to develop crop management adaptation strategies (Mugabe *et al*., 2010).

However, in Limpopo some farmers highlighted that they have somewhat lost interest in their farming practices, since their farming practices are by trial and error and the indicators that they use to help them to predict weather are slowly disappearing. As opposed to other studies where farmers mainly used IKS, they were reported to be less responsive towards modern information. In this study, the subsistence producers seemed to be open to change as they realised to a certain extent that reliance on IKS only limited their prosperity in farming. The resources that were previously used to predict weather patterns and to call upon the rains were no longer available and accessible. This is an opportunity for subsistence to be exposed to climate change interventions as an alternative to effectively cope with climate changes, since they no longer have the indigenous indicators to help them predict the weather. Therefore, Kalanda-Joshua (2011) argues that there is a need for the integration of indigenous knowledge systems and scientific climate forecast for better adaption to the climatic variability. This can be done in the study area by having farmers days workshops/training were scientific people can share recent information with farmers.

Smallholder farmers' awareness of climate change and available interventions

In all study areas about 78% of the farmers exclusively relied on IKS and 67.3% claimed not to have ever heard of the concept of climate change. Furthermore, 93.3% of the farmers had never been trained on climate change interventions with only 6.7% having received some form of training (Table 7). Therefore, this calls for the interventions of the government (extension officers) and NGOs to come together and train the farmers regarding the climate change concept.

Table 7: Climate change awareness and interventions in Limpopo province

	Frequency (n=150)	Percentages (%)
Climate change awareness		
Yes	49	32.7
No	101	67.3
Climate change interventions		
Available	31	20.7
Unavailable (IKS)	117	78
Climate change interventions		
Trained	10	6.7
Never been trained	140	93.3

These findings are in agreement with previous studies that indicated that, in rural Limpopo the concept of *'climate change'* was virtually unknown among farmers (Maponya and Mpandeli, 2012). Although the concept of '*climate change'* was unknown, the farmers had their own understanding and some observations noted on what was happening. According to the farmers the so called *'climate change'* was a day-to-day weather occurrence, that was observed through prolonged droughts and a significant decline in crop production due to lack of water. Therefore, there is also a need of weather stations (rain gauges) in the fields of these smallholder farmers communities as this will help them keep track of rain received yearly.

Perceived causes of climate change

The FGDs from all municipalities revealed that a majority of farmers were of the belief that *'climate change'* was the wrath of ancestors who are unhappy about the nations moving away from their traditional customs. Similarly, what Debela *et al.,* (2015) revealed that in South Ethiopia farmers with limited access to climate information attribute the extreme weather events taking place to a change in their rituals and culture. Only a few, who were mainly *food producers,* perceived climate changes to be caused by the changing environment as a result of human footprint and saw it as a natural process. The findings from the "*food producers*" in the current study are supported by Deressa *et al.*, (2011) that farmers will perceive climate change based on their farming experience. The perceived causes of climate change in Limpopo are presented in Table 8.

Table 8: Perceived causes of climate change by Limpopo smallholder farmers

Theme	Quotes
• Increasing sins committed by the people	• *"We have committed a lot of sins hence God is punishing us"*
• Angry ancestors	• *"We no longer practice our rituals"*
• Construction of buildings and roads	• *"We keep on cutting down the trees to build roads and houses"*
• Normal processes	• *"We do not really know what cause the changes, but we believe it is a normal process since the earth is moving"*

As shown in Table 8 smallholder farmers perceived supernatural forces as the primary cause of climate change. They used their experiences as points of reference, which in the past there was a

live interaction between natural resources and humans. Humans were then guarded and guided by the 'super power' referred to by some as ancestors and others were God. However, some rural communities in Africa are still influenced by beliefs and traditional ecological knowledge established within an ancestral spirit-world (Malicdem, 2015).

However, the equilibrium between the human and the natural resources is no longer reached through the actions heading towards modernisation. There is increased deforestation due to the growing population, as a result people are cutting down trees to develop infrastructure such as roads, industries, and houses etc. However, this is in contrast with what the World Future Council (2015) and Dunn (2009) have observed, they believe that agriculture is also directly responsible for climate change, because deforestation occurs to create more agricultural land, resulting in climate change. During the focus group discussions the subsistence farmers were adamant that IKS brought balance in human and natural resource systems. This shows the point of reference that is mainly used by the farmers to frame their perspectives and decisions.

Perceived availability of climate change interventions and support systems

Seventy eight percent (78%) of the farmers mainly relied on IKS because they were not aware of any climate change interventions and support systems available to them. The study findings are supported by a study conducted by Harvey *et al*., (2009), highlighting that climate change information in Africa is very limited especially in semi-arid regions due to illiteracy, lack of infrastructure and socio-economic factors. In the study area radio was regarded as the available and reliable support system by 39.3% providing weather forecasts and agricultural information; however it provided limited support with regards to warning signals and emergency guidelines. Extension services were also deemed to be available but were not reliable as they were not easily

accessible*: "They try but their knowledge is limited; at times we know better than them; their services arrive late; they do not know much about climate change."* The farmers revealed that IKS was the most available and reliable support system that was still working for them, as it was used to understand weather and climate patterns as well as making decisions about crops and farming practices: *"We rely on our old farming systems, our forefather's knowledge still works for us, we do not get any assistance from anyone so it's better we stick to what we know"*. Wisdom embedded from generation to generation knowledge transfer was the most available to farmers. However, this wisdom was also limited as the context and the times have since changed, but the subsistence farmers still used IKS as the best available alternative, similar to what was observed by Kalanda-Joshau *et al.,* (2011) revealing that IKS are no longer consistent due to high climatic variability.

However, it should be mentioned that not all the study areas shared the same sentiment, as in Musina the FPs had different result; the view was that the combination of extension services and NGOs provided a better service and support. As supported by different authors, Mandleni and Anim (2010), Deressa *et al.,* (2011) and Hassan and Nhemachena (2008) emphasized that having access to extension officers by smallholder farmers increases the probability of taking adaptation options. According to the focus group discussions the NGOs in this particular area informed farmers more about climate change while the extension officers had insufficient knowledge. But the working relation between the extension services and the NGOs proved to be beneficial to the FPs.

The role of social groups

The FGDs from Tzaneen, Maruleng and Mutale further revealed that the role of chiefs, church and traditional healers was not as much as it used to be in the past. However, with the *food producers* from Musina, church was an exception; the farmers revealed that they still value the role of church for support and prayers during hard times. The FGDs further highlighted that previously such social groups used to be the source of information, wisdom and support. In this study they were available but deemed not valuable to provide any information or support due to lack of relevance with the issues on climate change (Figure 6 and 7). There was a shift observed from valuing the interactions between the natural resources and human interactions due to increasing competition between these systems associated with modernisation and urban migration. The lack of human responsibility towards the natural resources was interpreted as ancestors' wrath. The farmers need relevant and reliable systems that will provide them with early warning systems, predict weather patterns, and provide information on seed selections as well as agronomic practices that could reduce their vulnerability to climate change.

Accessibility of climate change intervention and support for subsistence farmers

IKS, radio and farmer to farmer advice were rated as good accessible, reliable, timeous and easy to use institutions for disseminating climate change information to subsistence smallholder farmers. However, their accuracy and the depth of content level were rated moderate due to irrelevancy of the current forecast. In support of these results is a study conducted by Cherotich *et al*., (2012) who revealed that women were said to prefer radio whilst the elderly people preferred local indigenous knowledge systems. This is, however, in contrast with CGIAR (2014) who indicated that women preferred to access information from extension officers. Agricultural

advisors and NGOs were said to have a moderate level of accuracy and good depth of content, yet when it comes to timeliness, accessibility, and reliability they were rated poorly (Table 9).

Table 9: Accessibility of climate change institutions/organizations for SPs

	Timeliness	Accuracy	Accessibility	Reliability	Ease of use	Depth of content
IKS	*	**	*	*	*	**
Radio	*	**	*	*	*	**
Farmer to farmer	*	***	*	*	*	**
agricultural advisers	***	**	***	***	***	*
NGOs	***	**	***	***	***	*

Key: Good = *Moderate = **Poor = ***

According to the FGDs agricultural advisers (extension officers) were proclaimed as important but less useful due to inaccessibility of their services. Agricultural extension officers are the closest resource of information and support to advise farmers on how to make informed decisions to cope and adapt better to climate change as stated by Etwire (2012). However, in this instance extension did not provide timeous services and they were not well equipped to share any climate change knowledge as they lacked it too.

Table 10: Accessibility of climate change institutions/organizations for FPs

	Timeliness	Accuracy	Accessible	Reliability	Ease of use	Depth content
Church	*	*	*	*	*	**
NGOs	*	*	*	*	*	**
agricultural advisers	**	*	*	*	*	**
Farmer to farmer	**	**	**	**	*	***
IKS	***	***	***	***	**	***

Key: Good = *Moderate = **Poor = ***

FPs however had different opinion from the subsistence farmers. They rated Agricultural advisers, NGOs and church to be accessible, reliable, timeous for disseminating climate change

information. However, IKS was rated to be less important and useful to them as they received most of their information and support from the agricultural advisors and NGO (Table 10).

Therefore, the FGDs highlighted that the agricultural advisers (extension officers) and NGO were important and useful due to accessibility of their services. They also rated church as a very important useful institution because they believed that church is the starting point for everything, it is through prayer that they have all the support they get, the resource and inputs available to them. Therefore, in this instance the extension services and NGO provide timeous services.

The perceived importance and usefulness of institutions/organizations to subsistence smallholder farmers

As shown in Figure 6, IKS was ranked as the most important and useful resource of information and support among the subsistence farmers. The second ranked was media (radio &television) they at least; *1) predicted the weather; 2) used suitable language and provided the programmes at appropriate times for the farmers to listen; 3) provided broader advise on agricultural information.* The third ranked were extension officers who were perceived to be important but less useful due to various limitations such as: *limited knowledge and skills about climate change; compromised trust due to delayed services; overburden of extension officers with responsibilities (1 officer to 300 farmers).* Radio complemented the IKS in this instance.

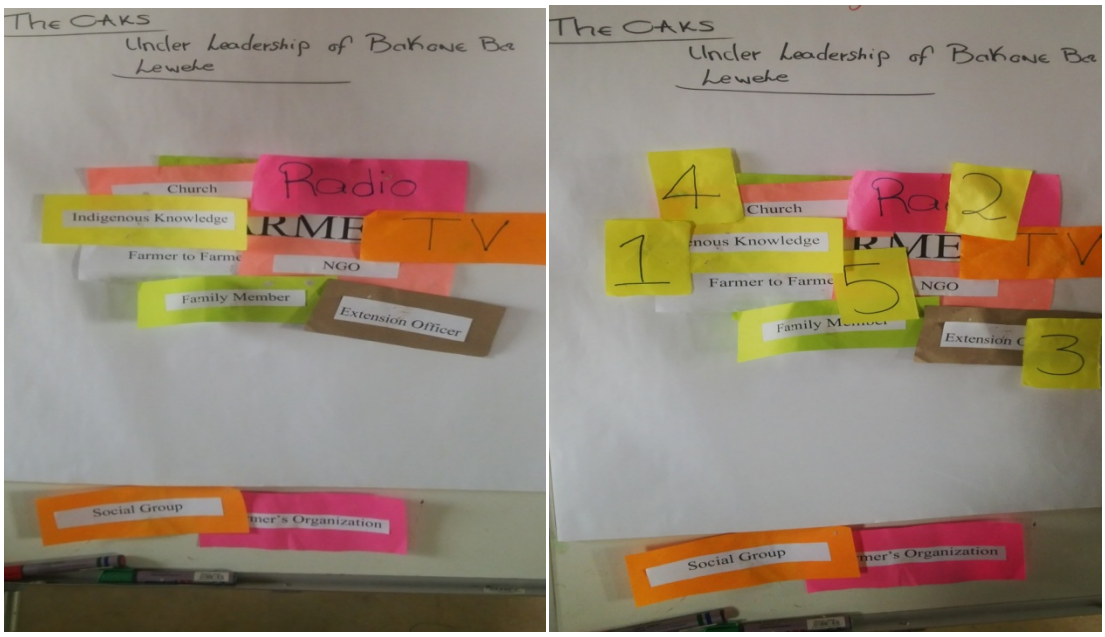

Figure 6: Venn diagrams showing the importance and usefulness of institutions for subsistence farmers.

The subsistence Venn diagrams within all three municipalities (Tzaneen, Maruleng and Mutale) shared similar trends. The farmers perceived NGO's not to be useful and were less important due to trust issues. The farmers felt that they were being disempowered by the NGOs as their knowledge was often disregarded and they usually recommend services and technologies that were impractical and costly. There were similar experiences and opinions between the SPs and the farmers who were producing for both subsistence and selling.

However, the findings differed with the FPs Venn diagram, church was perceived to be very important as that is where they get to communicate with their God and ask for rain. Extension officers and the NGO ranked as the most important and useful resource of information and support among the FPs. They provided inputs such as fertilizers and were hands on when it came to farm visits. They were available and accessible to (Figure 7).

Figure 7: Venn diagrams showing the importance and usefulness of institutions for FPs (Musina)

There is a need to build capacity among all stakeholders involved in smallholder farmer's production systems to enable them to provide the necessary support on how to predict, interpret and develop early warning systems to reduce vulnerability, enhance adaptability and increase resilience. However, trust was declared as the fundamental factor that could influence the interactions and usefulness of these institutions/organisations as support systems among subsistence farmers.

Not only climate change interventions and support systems were not accessible to subsistence farmers, but access to agricultural support systems was also a big challenge to the farmers (Table11).

Table 11: Challenges facing smallholder farmers

Question	Theme	Quotes
What are the challenges?	• Lack of extension services and support	*"We know we have extension officers but they don't come to assist us"*
	Inputs: • Seeds and fertilizer	*"We sometimes get inputs like seeds and fertilizers, but we always receive them very late"*
	• Accesses to information	*"We do not receive any information on climate change, and we never attended any workshop or trainings on climate change. we just ask each other for advices or listen to the radio for weather forecast "*
	• Irrigation systems	*"We wait for the rain, if there is no rain we just wait and see.*

Agricultural support services were reported to be a major challenge which affected their agricultural systems. The respondents indicated that they received inputs after planting season has passed; they rely mainly on their indigenous knowledge and amongst each other for information and support.

Gender access and preferences

Gender differences with regards to accessibility of climate information were of concern in this study. Social position of women in the family and the community, social norms and power structures, both genders had different roles at a household level; hence there were different preferences in accessing climate change information between genders, these findings were also supported by (Cherotich *et al.,* 2012). During the focus group discussions men seemed to have better access to climate information than women. Women and elderly people had more access to

the IKS and radio because most of them were old and illiterate so they cannot read nor write, whilst most men had more access to extension officers it was easy for them to communicate with them, media such as TV and newspapers because most of them could read and had time to watch TV unlike women. These findings were supported by UNEP (2011) based on the fact that subsistence women relied on their IKS for information, the study on 'Women at the frontline of climate change' highlighted that women have valuable indigenous knowledge about managing their environments and technical know-how in relation to agriculture.

As stated above, there were different channels preferred among men and women to disseminate and access climatic information. The subsistence female farmers preferred radio because they stated that "*We prefer radio because we can continue with our daily chores while listening, radio doesn't require us to sit while listening and the information is disseminated in our own local language, it is also reliable because we know the exact time the programmes starts so it doesn't clash with our daily schedules.*" However the FPs female farmers showed different findings, they preferred to access information from extension officers, through more personal contact than men. This is because the farmers argued that they get to ask direct questions and some things are done practical for them. The CGIAR (2014) had similar findings in their study as well and this gave the farmers the opportunity to interact with the extension officers, and get relevant advices.

4.8 Conclusion and recommendations

The study has shown that most smallholder farmers in Limpopo province were not aware of climate change interventions available and accessible to them. The farmers' experienced a serious lack of information that would help them to adapt. Smallholder farmers were not receiving information to help improve their farming systems. As a result some farmers adapted

to the changing climate using information shared among themselves and their indigenous knowledge systems. Therefore, there is need to bring awareness of the implications of climate change to the farmers. Furthermore, there is a need to consider indigenous knowledge system-based climate change support and interventions to empower farmers with capacity to withstand climate change challenges. There is a need to put climate change interventions on the agenda of the department of agriculture so that extension officers are trained to enable them to assist farmers.

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Chapter 5: Smallholder farmer's perceived effects of climate change on crop production and household livelihoods: *a case study of smallholder farmers in rural Limpopo province, South Africa.*

5.1 Abstract

Climate change threatens various sectors of economic development including natural resources, agriculture and food security, forestry, tourism, manufacturing and health. The study investigated the perceived effects of climate change on crop production and household livelihoods of smallholder farmers in Mopani and Vhembe district municipalities, Limpopo. Data was collected through a survey questionnaire administered to a random purposive quota sample of one hundred and fifty smallholder farmers. The questionnaires were complemented by 8 focus group discussions withdrawn from the survey for further probing. Secondary data and transect walks triangulated the above mentioned tools. Multinomial logistic regression model (MNL) was also used to analyse the factors influencing smallholder farmers' choice of climate change adaptation strategies. The study findings revealed that subsistence farmers perceived prolonged droughts (56.4%) as the main shock stressing their production whilst other farmers were of the opinion very hot seasons were the significant shock (56%). The events led to low crop yield and high crop failure (73.3%) consequent to food insecurity. In response to the prevailing climatic condition different gender adapted different strategies, 41% of female farmers adapted to changing planting dates, while male farmers employed crop variety and diversification (35%) and mixed cropping (15%) better than female farmers. The farmers who were aware of climate change had a positive significant impact in changing planting dates ($p<0.01$) as an adaptation strategy. Female smallholder farmers seemed to be more vulnerable to climate change impacts due to their age, health status affecting physical activeness and low literacy levels as compared to their counter parts; hence they were hit hard by the climatic variability and experience major

crop losses (68.7%). The smallholder farmers were vulnerable with limited adaptive capacity to withstand climate change due to compromised social, human, physical, natural and financial assets. The results showed that smallholder farmers tend to adapt better when they have access to extension officers ($p<0.01$). Therefore, it is important for the government to strengthen the relationship between smallholder farmers and extension officers for the farmers to better adapt to the climatic shocks.

Keywords: Smallholder farmers, climate change, Well-being, Livelihoods, Food security.

5.2 Introduction

Climate change threatens various sectors of economic development including natural resources, agriculture and food security, forestry, tourism, manufacturing and health (IPCC, 2007; Meadows, 2006). This means that any change in climatic variables is, thus, likely to affect these sectors. The effects of climate change are characterised by changes in rainfall variability, increasing number of seasons without enough rainfall and increased temperatures which leads to extensive droughts and heat stress lowering crop productivity (Mandleni and Anim, 2010; Aune, 2012; Komba and Muchapondwa, 2012).

Climate change and variability has negatively affected the well-being of most rural smallholder farmers through its adverse impacts. Smallholder farmers in rural areas have been experiencing low agricultural productivity, crop failure, human disease outbreak, pest and diseases, lack of water, shortages of agricultural-based food items at a household level and food insecurities (Mutekwa, 2009). These impacts have posed a huge threat to food security and livelihoods of most farmers around the world compromising the well-being of rural smallholder farmers, as most rural smallholder farmers depend on natural climatic sensitive resources such as agriculture for their well-being (Debela *et al.*, 2015). Therefore, climate variability has been seen as a threat to their agricultural productivity which is mostly rain-fed (Maponya and Mpandeli, 2013). Climate change is set to hit the agricultural sector the most severely and cause suffering, particularly for smallholder farmers (Deressa *et al.*, 2009; Hassan and Nhemachena, 2008; Komba and Muchapondwa, 2015).

Agriculture is the largest known sector to be greatly impacted by climate change because of the size and sensitivity of the sector (Kurukulasuriya and Mendelsohn, 2008; Mendelsohn, 2009; Komba and Muchapondwa, 2015). According to Mendelsohn (2009) the extent of damage by

climate change to African agriculture will depend on future climatic scenarios, as well as the type and level of inputs used for agricultural production. Studies have revealed that the African continent is most likely to be affected by climate with prolonged droughts, reduced rainfall and increased temperature (Kurukulasuriya *et al*., 2006). Kurukulasuriya and Mendelsohn (2008) highlighted that the impacts will not be the same across the continent, the western, central and southern Africa areas are most likely to experience hotter and drier seasons. Climate change variation could bring both negative and positive effects as climate change is affecting the agricultural sectors of different countries in different ways. According to Komba and Muchapondwa (2015), the negative effects of climate change pose a great potential to result to extensive welfare losses especially for smallholder farmers in all countries since they depend mainly on agriculture as their main source of livelihood (Maponya and Mpandeli, 2013). Climate change is characterised by droughts and floods, which destroy plants and depletes the soil. Aydinalp and Cresser (2008) supports this argument by highlighting that there are frequent droughts that have been observed over the past decades reduce soil moisture and water resources for plants, consequently resulting in severe water stress. Reduced soil moisture hinders plant growth in non-irrigated agriculture.

Smallholder farmers are vulnerable to the effects of climate change due to their marginal location, low levels of technology, limited access to climate information and lack of other essential farming resources resulting in low livelihood assets and vulnerability to household food insecurity (Thamanga-Chitja and Morojele, 2014). Therefore, it is important for smallholder farmers to be aware of the effects of weather patterns in the immediate and long terms, so that they can employ adaptation measures such as planting different varieties of the same crop, mixed

cropping and water conservation practices (Gbetibouo *et al.*, 2010; Komba and Muchapondwa, 2015). Moreover, studies conducted by Below *et al.,* (2012) and Komba and Muchapondwa (2015) revealed that adaptation methods used by farmers are measures that are relatively inexpensive such as changing planting dates and diversifying crops, while those that are costly or require more capital such as irrigation systems were used by very few smallholder farmers. Turpie and Visser (2013) argue that adaptation strategies such as crop diversification, changing planting and harvesting dates are cost–effective with a potential to bring balance on the farming systems of smallholder farmers. However, Nhemachena and Hassan (2007) emphasised that these adaptation measures can only be achieved through smallholder farmers themselves taking adaptive initiatives or by governments implementing policies that support and promote appropriate and effective adaptation measures

The African continent is already suffering from food insecurity and malnutrition, Folaranmi (2012) highlighted that about 23 million people in 11 African countries are affected by acute food insecurities and facing malnutrition. Climate change in this continent exposes smallholder farmers to worse hunger scenarios (Apata *et al.,* 2009). The impact of climate change will bring substantial losses especially to smallholder farmers whose main source of livelihood derives from agriculture. Such impacts can be significantly reduced through adaptation of appropriate strategies. Given the high dependence on rain-fed agriculture and prevailing drought conditions in semi-arid regions such as Limpopo (LDA 2012), the area may be quite vulnerable to the current and future climatic changes. Ziervogel *et al.,* (2014) revealed that there are well-established concerns of climate changes in South Africa, however, there is little information on the negative effects of climate variability on the well-being of smallholder farmers, and hence,

this study aimed to investigate the effects of climate change on the well-being of smallholder farmers in rural Limpopo province, South Africa.

5.3 Materials and Methods

5.3.1 Description of the study area

The study was carried out in Limpopo province (Figure 3) within two district municipalities namely Mopani (23.3167^0 S, 30.7167^0 E) and Vhembe (22.9333^0 S, 30.4667^0 E). The Mopani District (Figure 4) is situated in the North-eastern part of the Limpopo Province covering an area of about 25 344, 13 km^2 in the province, with farming as the second largest employer in the district. However, this district is characterized by low rainfall in Tzaneen and Maruleng municipalities (between 400mm to 900mm), resulting in limited water resources causing severe water shortages and regular drought conditions particularly in the lower-lying areas of the district. Vhembe district (Figure 7) is located in a semi-arid area that is frequently affected by dry spells, often growing into severe drought. The district is the most northern district of Limpopo province with a rainfall pattern ranging between 246mm to 681mm per annum in Musina and Mutale local municipalities respectively. Vhembe district covers an area of about 25 592 km^2 which is predominantly rural, with a population size of about 1, 294,722 people (Census, 2011). As reported by the LDA (2012) the two district municipalities were the most vulnerable to climate change experiencing extreme climatic risk as well as high climate variability in the province.

5.3.2 Methodology

Both quantitative and qualitative methods were used to collect data in the study. The quantitative research method was used to compare responses across the participants since they were asked identical questions in the same order. On the other hand, the qualitative research method was

used to seek understanding of the farmer's perspective or situation by regarding the participants as experts of their situation. This methodology was found appropriate for this study because the study aimed to find meaningful answers and experiences of farmers with regards to the impacts of climate change on smallholder farmer's livelihoods and food security.

5.3.3 Research design and sampling technique

A representative population of 150 smallholder farmers in Mopani and Vhembe participated in this study. The local extension officer of each local municipality provided a list fitting the stated criteria and the smallholder farmers were randomly selected from each local municipality.

The focus group discussions (Appendix B) participants (between 9 and 14 per session) were also selected using the same criteria, however; these were farmers who volunteered to be part of the discussions. A trained facilitator who spoke the local language conducted the focus group discussions. A tape recorder and video were used to document the sessions with the consent of the participants. With regards to the transect walks (Appendix C), a small group of 5 farmers who fitted the criteria but did not participate in the focus group discussions were selected in 4 local municipalities namely: Tzaneen, Maruleng, Mutale and Musina.

5.4 Validity and Trustworthiness

The questionnaire (Appendix A) was pre-tested to a small group of smallholder farmers around the study areas and they did not participate in the study. This was done to ensure that the translation from English to siPedi was accurate and to pick up ambiguous questions. Enumerators were trained thoroughly to understand the questions. Furthermore, the focus group discussions were conducted by a trained facilitator who speaks the local language. Towards the end of each session the facilitator provided a summary of the discussion and the participants

were asked to verify the information collected. The transect walks, focus group discussions and the survey tools triangulated each other. Questionnaires were administered to individual smallholder farmers and key informants from each district municipalities helped with the provision of a list of active smallholder farmers in the local municipalities.

5.5 Ethical considerations

Permission was granted by the Provincial Limpopo Department of Agriculture, the local municipalities and the extension officers gave authorisation (Appendix D). The smallholder farmers provided oral and written consents before the beginning of each session (Appendix A). The study findings and recommendations will be present back to the communities in completion of the study.

5.6 Data analysis

A Statistical Package for Social Sciences (SPSS) version 23.0 was used to capture data. Data collected was manually coded and analyzed using descriptive statistics. Microsoft excel 2010 statistical package and STATA version 8 statistical package were used. The coded demographic data provided a general overview of who is mostly involved in farming, the age group that is most active as well as information with regards to the heads of households. Multinomial logit regression model was used to analyse the factors influencing the choice of climate change adaptation strategies by smallholder farmers. The estimation of the Multinomial logit regression model (MNL) was made by normalizing one category, which is normally referred to as the "base category." In this analysis, "no adaptation" option was used as the base category. This model specification was used by several researchers to model climate change adaptation practices of smallholder farmers in Africa (Deressa *et al.*, 2009; Nhemachena and Hassan, 2008).

Frequencies were done in order to investigate smallholder farmers' awareness of climate change and their demographics. Focus group discussions transect walks and secondary data were analyzed through content analysis by identifying themes, concept, patterns and trends.

5.7 Empirical Model

Multinomial logit regression model (MNL) was used to analyse the factors influencing smallholder farmers' choice of climate change adaptation strategies. MNL model for choice of adaptation strategies specifies the relationship between the probability of choosing an adaptation option and the set of explanatory variables (Magombo *et al.*, 2011). It was established that the sampled smallholder farmers were following three adaptation strategies namely: Crop and variety diversification, changing dates of planting and mixed cropping. It should be mentioned that there were those who were not practicing any adaptation strategies.

The MNL model was specified as follows:

The dependent variable was the participation status (i.e. 1 = Not adapting; 2 = Crop and variety diversification; 3 = Mixed cropping; 4 = Change planting dates).

Letting P_j (j = 1,2,3) be the probabilities of a smallholder farmers being in each adaptation strategy and assuming that j =1 is the reference category, the multinomial logit model showing the relative probabilities of being in the three participation categories as a linear function of X_{ki} for the i^{th} household, according to Greene (2003), is estimated as:

$$\ln (P_j/P_1) = \log (P_j/P_1) = \beta_{0j} + \beta_{1j}X_{1i} + \ldots \beta_{kj}X_{ki} + u_{ji} \quad (1)$$

For j = 2, 3 and i = 1, 2...n farmers where:

- ln = the natural logarithm (or $\log_e$)
- P_1 = the probability of the smallholder farmers being in the reference category (Not adapting);
- P_2 = the probability that the smallholder farmers diversifying crop varieties
- P_3= the probability that the smallholder farmers are adapting mixed cropping

• P_4 = the probability that the farmers change planting dates

• β_{kj} are the MNL coefficients to be estimated and,

• X_{ki} is the k^{th} explanatory variable explaining the i^{th} farmers

In this study, the category "not adapting" to climate change variability was used as the reference category. A brief description of the explanatory variables used in the multinomial logit model is provided in Table 12.

Table 12: Variables used in the multinomial logit model to explain participation status

Independent variable	**Description**
Age	Continuous variable for farmers age
Gender	Dichotomous; 1 if individual is male and 0 otherwise
Marital status	Dichotomous; 1 if individual is married and 0 otherwise
Education	Continuous The level of household head's formal education
Farming	Dichotomous; 1 if farming is the main source of income and 0 otherwise
Years of Experience	Continuous variable for household head's age
Land Fertility	Dichotomous; 1 if land is fertile, and 0 otherwise
Extension Availability	Dichotomous; 1 if extension services is available to farmers, 0 otherwise
Climate awareness	Dichotomous;1 if smallholder farmers were aware of climate change, 0 otherwise
Reliability	Dichotomous;1 if they rely on farmer to farmer for climate information and 0 otherwise
Rain-fed	Dichotomous;1 if smallholder farmers rely on rain fed irrigation, and 0 otherwise
Training	Dichotomous;1 if access to extension services, and 0 if no extension services
Hectares	Dichotomous;1 for hectares greater than 1 and less than 2.5ha, and 0 otherwise
Mutale	Dichotomous;1 for smallholder farmers in Mutale, and 0 otherwise
Tzaneen	Dichotomous;1 for smallholder farmers in Tzaneen, and 0 otherwise
Maruleng	Dichotomous;1 for smallholder farmers in Maruleng, and 0 otherwise

5.8 Results and discussion

Vulnerability of smallholder farmers to non-climatic and climate change shocks

Smallholder farmers in this study were affected by both climatic shocks and non-climatic shocks. The smallholder agricultural sector was mainly dominated by elderly women (64%) of which 40% were between the ages 60 to 69 years and 60% of these women had no formal education. This trend verifies the previous reported active involvement of women in smallholder agriculture activities as they bear the primary role of providing food for the family (Cherotich *et al*., 2012). The findings also confirmed that the smallholder agriculture is dominated by older women. These are women who are the custodians of farming knowledge, therefore if agricultural development and climate change interventions as support systems are to be designed, the dominance of the older women generation and their knowledge should be considered for future engagement of women in farming. On the other hand as shown by Ncube (2012) the dominance of older women in farming could indicate limited physical abilities (prone to illnesses), less adaptability and reluctance to move away from the 'norms'. Therefore, labour saving technologies need to be prioritized.

Ninety four percent of the households were headed by men and 44% of the men had no formal education. Ncube (2012) stated that the low education level tends are a hindering factor in accessing relevant information from various media sources since reading could be a challenge. Furthermore, the limited education of both men and women poses a constraint to job opportunities thus weakening household economic status and it even threatens future development interventions. The estimated income for the majority of the female farmers in these study areas ranged between ZAR801-R1500 (64%), and for male farmers it was up to ZAR3500 (Table 13). The bigger amount of ZAR 3500 was merely for a 6% of the male farmers who had

access to part-time jobs such as being constructors. Nevertheless, the majority of the farmers had diversified sources of income such as pension (43%) and social grant (10%) for sustaining their livelihoods (Table 13). Most of all agricultural activities played an important role in providing much needed subsistence for the farmers as 57% of male and 44% female farmers generated their income mainly from farming. Cash income in these study areas was obtained from selling farm produce, as stated by Mudhara (2010) that smallholder farmers use agricultural production as the cornerstone of their livelihoods. They practice other activities, in addition to farming, such as wage labour, crafts or petty trading for income generation. These findings are also similar to what was revealed by Statistics South Africa (2012) that in most rural areas farmers used a variety of livelihood strategies such as wages, salaries, social grants and pension remittances.

Table 13: Smallholder farmers' sources of income in Limpopo

		Gender (%)	
		Male	Female
Total household income per month	Below ZAR800	19	16
	ZAR801-ZAR1500	52	64
	ZAR1501-ZAR3500	20	11
	Above ZAR3500	9	9
Which of the income sources is the major source of income	Pension	31	43
	Farming	57	44
	Part-time job	6	2
	Remittances	0	1
	Social grant	6	10
Total % for the different Gender		36	64

Despite the reported diversified livelihood strategies, the smallholder farmers still remained vulnerable to poverty and food insecurity because their livelihoods still provided insufficient means of survival. This situation indicates the sensitivity of smallholder farmers towards climate change as agriculture is their main source of income and their livelihood option is farming.

Health status of the respondents

The respondents in this study highlighted poor health as one of the negative factors hindering them from achieving high crop yields. This finding confirms the statement made by Ncube (2012) that age can be a correlating factor for ill health, compromising the efficiency of production. As stated above that the most active group in farming was between the ages 60 to 69 years, during the focus group discussion, the smallholder farmers highlighted sicknesses such as painful joints, high blood pressure, hypertension, heart diseases, diabetes and tuberculosis to be giving them problems, in that order of importance. The farmers also stated that they were no longer fit enough to stay in the field the whole day like they used to, as their energy levels were no longer the same as 10 years back, therefore, this resulted in decreased crop production, compromising their food security status as farming was the main source of income for a majority of farmers in the study areas. The results also revealed that female farmers seemed to be at more risk than male farmers, as they dominate the farming sector and majority were in poor health (32%), therefore, this affects the household livelihood.

Household food security and coping strategies

According to the respondents the climate change had a negative effect on their household food security status due to crop losses experienced over the years. Female farmers (54%), were found to be more vulnerable as they reported to have experienced very severe losses of agricultural

based food over the past 10 years whereas the losses for male farmers were moderately severe (46%) (Table14).

Table 14: Perceived crop production losses and coping strategies by smallholder farmers in Limpopo

		Gender (%)	
		Male	Female
How severe has the crop loss been over the past 10 years	Very Severe	52	54
	Moderately severe	46	38
	Not severe	2	7
How did you cope with these shortages?	Eat less food	37	26
	Change diet	22	35
	Borrowed money	19	18
	Received food from relatives	13	11
	Sent older children away to work	9	9
Total % for the different males and females in the study		36	64

Therefore, to deal with these challenges the smallholder farmers had different coping strategies to sustain themselves. Eating less food was the most practiced strategy among male farmers (37%) so to make sure there was enough for the rest of the family and for female farmers was changing their eating diet (35%). These results show a negative effect on the food security status of the smallholder farmers, because food was neither always available nor accessible, therefore, could not utilize their preferred meals and there was also a lack of stability. Therefore, the four pillars (availability, accessibility, utilization and stability) of food security were compromised among these farmers negatively affecting their well-being.

It could be therefore argued that the smallholder farmers' under study are vulnerable to the non-climatic shocks. It exposes them to food insecurity and poverty, and consequently to limited and compromised livelihood options since farming is their main source of income. Identified factors such as the age, health status, level of education and gender seemed to be the major factors that exacerbate the smallholder farmers' vulnerability to climate change, exposing them to food insecurity and reducing the viability of livelihoods. As suggested by Ncube (2012) climate change should not be divorced from developmental policies. Hence, the study suggests that climate change should form part of the Food and Nutrition Security related policies, plans and programmes, and the engagement of youth to overcome "the energy crisis" and literacy problem to access climate change information should also be encouraged.

Climatic shocks

Smallholder farmers in the study areas were exposed to a number of shocks and stresses that affects their livelihoods. The farmers highlighted that they have been experiencing prolonged droughts, heat waves, increased dry seasons and reduced rainfall seasons which led to frequent livestock deaths, human disease outbreaks, crop failure, reduced yield and food insecurities over the past 10 years (Table 15). This was also highlighted by the key informants of the local municipalities.

Table 15: Climatic shocks observed by smallholder farmers

Type of Farmers	Floods	Prolonged droughts	Very hot seasons	Haven't observed any changes
Subsistence farmers	7.4%	56.4%	29.8%	6.4%
Farming for selling and consumption	0%	44%	56%	0%

Food producers	3.2%	41.9%	54.8%	0%

Note: $p<0.05$

The study findings revealed that different type of farmers had experienced different climatic shocks over the past ten years. Prolonged droughts were observed to have increased (51.3%) as well as very hot seasons (39.3%). About 5.3% of the farmers observed increase in floods, and of them majority were subsistence farmers (7.4%), with only 4% of the farmers stated not to have observed any climatic changes (Table 15). Note should be taken that the subsistence farmers perceived prolonged droughts (56.4%) as the main shock stressing their production whilst other farmers were of the opinion very hot seasons were the significant shock (56%;54.6%). The ($p<0.05$) elaborate that the farmers who mainly relied on rain-fed which were mostly the subsistence farmers, who perceived drought to be most climatic shock they were vulnerable to. To further confirm these findings, during the conduct of the research, observations were made that the subsistence farmers had not planted anything because there were no signs of rain in areas such as Tzaneen and Maruleng.

Adaptation to climate by smallholder farmers

Over 65% of women farmers claimed not to have heard about climate change whilst 56% of the males had some idea. Furthermore, in this study, different gender adopted different adaptation strategies better. Male smallholder farmers (35%) adapted by employing crop variety and diversification better than female farmers (21%). About 41% of the female smallholder farmers employed the changing dates of planting strategy better than males farmers (39%), which involved delaying the common planting season. 15% of male farmers also preferred mixed cropping better than female farmers (10%). Male farmers seemed to adapt better than female farmers in this study area, since they were more flexible to adapt as they used more adaptation

strategies. This might be due to the fact that a majority of men were aware of climate change (Table 16).

Table 16: Awareness and adaptation strategies to climate change of smallholder farmers in Limpopo

		Male and female (%)	
		Male	Female
Have you ever heard about climate change?	Yes	56	35
	No	44	65
Level of Education	No Formal education	44	60
	Primary	22	24
	Secondary	28	15
	Tertiary	6	1
What adaptation measures have you used to deal with the changes in temperatures?	Crop and variety diversification	35	21
	Changing dates of planting	39	41
	Mixed cropping	15	10
	None	11	28

These findings revealed that most of female smallholder farmers (Table 16) are not adapting very well to climate variability, because a high proportion was not aware of it, hence it was difficult for them to employ different adaption strategies. Lack of support services to disseminate climate information and high level of illiteracy (60%) among smallholder farmers might be another hindering factors for them, since they are unable to read and understand (e.g. weather forecast) and keep up with what is happening around them. Poor adaptation strategies put the well-being of the smallholder farmers at risk, because they find it difficult to cope. Therefore, farmers need support systems that will disseminate information about climate change and keep them updated in order for them to respond to the climatic threats (IFAD, 2010). These results show that the

climate change is perceived differently by men and women, and they adapt differently to its effects. Therefore, climate change interventions and support systems should take special attention of the gender dynamics.

Determinants of farmers' choice of adaptation strategies to climate change

Multinomial logistic regression analysis was estimated to determine the factors influencing a smallholder farmers' choice of adaptation strategies to cope with the impacts of climate change (Table 17).

Table 17: Multinomial logistic regression estimates for the choice of adaptation strategies

Adaptation	**Crop and variety**			**Changing planting dates**			**Mixed cropping**		
	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z
Age	-0.21	0.35	0.55	0.28	0.36	0.43	0.61	0.44	0.16
Gender	-0.83	0.78	0.29	-0.46	0.79	0.56	0.07	1.00	0.95
Marital status	-0.26	0.63	0.68	-0.38	0.65	0.57	-0.53	0.82	0.52
Education	0.56	0.44	0.20	0.63	0.44	0.15	0.37	0.56	0.51
Farming	-1.45*	0.81	0.07	-0.51	0.85	0.55	-1.10	0.94	0.24
Long	-0.24	0.33	0.47	0.12	0.32	0.70	-0.66	0.42	0.12
Fertile	0.46	0.61	0.45	0.37	0.61	0.55	0.66	0.76	0.39
Extension	0.66	1.01	0.52	0.89	0.96	0.36	-0.14	1.50	0.92
Climate awareness	1.99**	0.75	0.01	2.51***	0.76	0.00	1.61*	0.96	0.09
Mutale	-0.74	1.34	0.58	-1.08	1.16	0.36	1.09	1.55	0.48
Reliable	0.33*	0.19	0.09	0.27	0.20	0.17	0.05	0.24	0.83
Rainfed	-0.17	0.78	0.83	-1.03	0.72	0.15	-1.28	0.92	0.16
Training	-0.17	1.05	0.87	16.94	1499.71	0.99	-0.46	1.22	0.71
Tzaneen	-0.21	1.13	0.86	-2.28**	1.12	0.04	0.07	1.46	0.96
Hectares	0.77	0.60	0.20	-0.42	0.53	0.43	1.25*	0.72	0.08
Maruleng	16.35	1141.15	0.99	17.10	1141.15	0.99	17.20	1141.15	0.99
_cons	-0.69	2.51	0.78	-17.04	1499.71	0.99	-2.80	3.07	0.36

*** = values statistically significant at 0.01 probability level, ** = values statistically significant at 0.05 probability level, * = values statistically significant at 0.10 probability level
Base category: not adapting
Number of observations: 150

From the above table (Table 17) the results indicate that farming as a source of income for smallholder farmers has a negative impact on improving crop varieties and diversification for farmers. Similar conclusions were made by Yila and Resurreccion (2013) that being a smallholder farmer with little surplus income hinders the expansion of some climate change adaptation strategies. This means that it is not easy for smallholder farmers to employ adaptation strategies based on their income from farming, because income alone without awareness will not assist them to adapt better.

The adaptation options for smallholder farmers are also determined by the farmers' awareness of climate change. The study findings highlights that being aware of climatic change variability has a positive significant impact towards adapting to crop variety and diversification. Smallholder farmers who are aware of climate change have a high probability of employing combination of adaptation strategies. Being aware of the changing climate has a positive significant impact on the adaptation of changing planting dates ($p<0.00$) and mixed cropping ($p<0.09$) because farmers are always updated on what is happening around. Indeed, it is an important precondition for farmers to take up adaptation measures (Maddison, 2006).

The findings further reveal that access to extension services for climate change information increases the likelihood of smallholder farmers adapting to new crop variety and diversify their enterprises ($P<0.09$). This is because access to extension service assists farmers through educational trainings; help them improve their farming methods and techniques through the provision of up-to-date information (FAO, 2010). The study findings are similar to Tazeze *et al.*, (2012) found in Ethiopia, that having access to extension services increases the probability of using improved crop variety and soil and water conservation techniques. Extension officers are most likely to influence decision of farmers to use other type of adaptation strategy to cope up

with adverse impacts of climate change. Access to land size greater than 1 ha and less than 2ha has a positive and significant impact on the likelihood of using mixed cropping strategy by 0.08%. Being from Tzaneen local municipality has no significant impact on adapting to changing planting dates. Meaning that being from a certain areas (municipality) does not determine the adaptation strategies for farmers.

Table 18: Livelihood assets and adaptation capacity of smallholder farmers' in Limpopo

Livelihood assets	Description of sensitivity and vulnerability of the smallholder farmers
Human	o 65% of female smallholder farmers have never heard of the concept climate change o 56% of men revealed to have known about climate change. o 76% were in good health to enable labour but % of women had compromised health o 54.7 %have no formal education
Social	o 8.7 % only had access to social networks o 30% only had access to social groups and these were mainly women
Physical	o 3.3% of farmers who have access on Irrigation infrastructure, o 10.7% Access to drought tolerant seed o 20.7% Access to interventions o 6.7% Access to support services
Natural	o 23.4% access to rivers and dams o 42% only had productive land and these were mainly the farmers who were producing for the market
Financial	o 0.7% access to Insurance o 3.3% Access to diversified income sources (part-time jobs)

The adaptation capacity of the smallholder farmers on human capital was affected by the low level of education within the farmers, since a majority of the smallholder farmers had no formal education (54.7%) and the active group was mostly old people between the age of 60-69 years, so it was hard for the farmers to search or read about climate change as only 8.7% had access to the internet (social networks) and only 30% had access to social groups, this shows how the social capital is affected in the area. Another limitation to the physical capital was lack of access

to physical infrastructure, as only 3.3% had access to irrigation schemes. Limited access to climate interventions (20.7%) and support services (6.7%) was also seen as a negative factor that hindered the farmers' adaptive capacity as well as lack of drought tolerant crops. About 23.4% of farmers had access to water from rivers and dams, these findings reveal that if there is no rain then these farmers do not have access to water for irrigation. The financial capital for the smallholder farmers was very unstable only 0.7% of the farmers had access to insurances to help them recover in case of disasters, meaning that if a disaster happens 99.3% of the farmers loss all the crops and did not have money to recover as only 3.3% have part-time jobs with the rest mainly depending on farming for income. The study findings reveal that the adaptive capacity of the smallholder farmers is determined by the five livelihood assets, therefore, lack of assets make it hard for farmers to easily adapt to the climatic variability and change.

Perceived effects of climate variation on smallholder farmer's livelihoods

Seventy seven percent of the respondents reported to have observed prolonged droughts over the 10 yrs and 33% mentioned heat waves. During focus group discussions the farmers confirmed that this climate variation was getting worse each year: *"We have not received any rain since beginning of January this year"* and the dry spells were reported to be worsening compromising their well-being. The climate variations were viewed as the consequences of shifting away from the indigenous/traditional systems and lifestyle (see chapter 4). The smallholder observations of climate variation which had an effect on domestic supply of water, was also confirmed report by the LDA (2012) on Mopani and Vhembe district municipalities, that they were the most vulnerable to climate change experiencing extreme climatic risks as well as high climate variability with an average rainfall between 246mm to 681mm per annum (Vhembe) and 400mm to 900mm in Mopani.

These frequent droughts have adversely affected the agricultural production as 68% of the smallholder farmers identified crop failure as the enterprise most impacted by the climate change. This is because a majority (72%) of the respondents had rain-fed fields and the agricultural sector is their source of livelihoods (see chapter 4). Similar findings were highlighted by Mpandeli and Maponya (2013) that in Limpopo Province the agricultural sector has been experiencing dry spells for a very long time, and negatively affecting rain fed agriculture. They further mentioned the years in which farmers experienced the most serious droughts in Limpopo Province, which were in the 1970s, 1980s, 1990s and recently 2000 - 2005, 2012 (Mpandeli and Maponya, 2013). Therefore, drought in Limpopo is a recurring prominent factor in crop production.

The focus group discussions held with the respondents highlighted that the climate change effects had a negative effect on the socio-economic aspects of the smallholder agricultural production and on their emotional status (Table 19).

Table 19: Negative effects of climate change on smallholder farmer's well-being

Type of effect	Theme	Concepts	Quotes
Negative	Socio-economic effect on agricultural production	Declining crop yields	*"Our production yield have dropped, so we experience food insecurities"*
		Increased water scarcity	*"there is no rain, hence no water, no crops"*
		Increased new pest &disease invasions	*"We keep on losing our crops due to new pests in our fields such as aphid attacks"*
	Emotional Effect	Loss of Hope	*"We keep on losing our crops"*
		Fearful	*"If these prolonged droughts persist and there's no rain, we are afraid we will die of hunger and food insecurity"*
		Helpless	*"The issue of climate change is beyond our control, there's nothing we can do"*
	Food and nutrition security status	Food availability and access compromised	*" We have not planted because there are no rains"*
			" Last year we did not plant we were waiting for rains, and we suffered"

As mentioned by the smallholder farmers the climate change over the past few years has resulted in prolonged droughts, reduced rainfall and very high temperatures which resulted in low crop yields. The smallholder farmers stated that lack of water for irrigation was another major challenge so the negative changes in rainfall patterns affected their livelihoods, because they end up delaying their planting seasons in anticipating for rainfall until it is too late in the season to plant. These findings support the LDA report (2012) that Limpopo province has been

experiencing extreme droughts, heat waves and reduced rainfall. These negative climatic effects compromise the well-being of the farmers as they experience food shortages.

Due to the erratic temperature changes and unpredictable rainfall the respondents have observed new pest and disease invasions. The farmers highlighted the “aphid attacks” of cabbage as one of the troublesome pests. The farmers have also noticed these invasions in summer during hot seasons. Similar results were highlighted by Komba and Muchapondwa (2012) that smallholder farmers’ production systems are directly threatened by the increasing temperatures that cause heat stress on plants, reducing water availability, lowering overall productivity and introducing new pests and diseases. According to the report by the IPCC (2007) the invasion of crops by pests and diseases were caused by the rising temperatures and changes in precipitation patterns. Therefore, the increasing temperatures result in great loss of smallholder farmers’ crop production. As some farmers highlighted during the FGDs even their indigenous ways of controlling pests seemed to be less effective, subsequently the new invasions infer some economic demands and unfortunately their knowledge seems to be limited on how to manage and control the pests (aphid attacks).

The negative effects of climate change have been seen to also affect the farmers emotionally. The prolonged droughts resulted in some of the farmers losing hope since they lost almost everything the previous year and it was still hard for them to recover from the loss. The farmers highlighted that they were aware of their vulnerability status towards climate as they are highly exposed to the negative impact of climate change mainly rainfall shortages (drought). The farmers also stated that they are now more confused and living in fear, as they are not sure whether to continue farming or not, since there is less rain due to prolonged droughts. These farmers greatest fear is that the agricultural sector is the driver of their well-being, so they are

bothered as unfavourable weather threatens their food security status and limits their livelihood options.

The focus group discussions revealed the smallholder farmer's willingness to progress and to adopt strategies that will mitigate the climatic stresses and threats. However they feel like the situation is beyond their control, thus feeling helpless since their indigenous knowledge which is cost-effective and most accessible seems to be outdated (see chapter 4). More so, there is limited or inadequate support systems provided to face the climatic risks.

5.9 Conclusions and Recommendations

The study findings revealed that climate change has a negative effect on smallholder farmers' livelihoods. Farmers have experienced extreme weather events such as droughts and reduced rainfall, yielding a negative effect in their crop production since there were lot of crop failures events due to prolonged droughts. The smallholder farmers worked around this situation by employing some coping strategies such as, eating less food a day, changing diet, borrowing money and some received food parcels from their relatives. These coping strategies, however, negatively affected the food security status of the farmers and compromised their well-being. Different gender among the smallholder farmers in the study area employed different adaptation strategies such as crop variety and diversification, mixed cropping which was mainly adopted by male famers and changing planting dates employed mainly by female farmers as a way of mitigating the climatic risks. Explanatory variables that were significant in influencing choice of smallholder farmers when adapting to climate change were, farming as the main source of income for sustaining their livelihoods, climate change awareness, reliance on extension officers as a source for climate change information who are unfortunately lacking climate change

knowledge and are supposed to provide support systems and interventions. Therefore, the government needs to ensure that the identified adaptation strategies are promoted and supported to help mitigate the climatic risks, and the interaction between smallholder farmers and extension officers should be strengthened. There is also a need to train extension officers on climate change and adaptation strategies, as well as other conservation agricultural practices so they could also disseminate correct and accurate information to the farmers, for better adaptation and improve well-being of farmers.

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Chapter 6: Conclusion and recommendations

The main conclusions and recommendations of the study are discussed in this chapter. The aim of the study was to determine the smallholder farmer's adaptation strategies and their perception towards climate change interventions and support systems. The specific objectives of the study were: (i) to determine climatic and non-climatic shocks faced by smallholder farmers; (ii) to evaluate smallholder farmers' understanding and awareness of climate change related interventions and support systems; (iii) to assess smallholder farmer's perceived usefulness of climate change related interventions and support systems in terms of availability and accessibility; (iv) to determine the smallholder farmers climate change adaptation strategies and what informs them.

6.1 Conclusions

The results of this study showed that in Mopani and Vhembe district municipalities agriculture is the back-bone and the primary source of the smallholder farmers' livelihoods. The study revealed that smallholder farmers in these municipalities were categorized in three groups: subsistence farmers who produced for household consumption and only sold seldom; then those who were farming for both household consumption and selling the surplus; and those who were referring to themselves as '*food producers'* because their primary goal was to sell to the market. However, the majority of smallholder farmers were not aware of climate change, the interventions available and accessible to them. The subsistence farmers more especially women were found to be the most vulnerable to climate change due to their high dependency on rainfall for their farming and lack of flexibility to employ different adaptation strategies. They also lacked access to extension services and basic farm inputs.

The smallholder farmers were affected by prolonged droughts, reduced rainfall and invasion of new pests and diseases such as aphid attacks. In order to counter these effects, the majority of smallholder farmers in Mopani and parts of Vhembe relied on their indigenous knowledge for their farming practices since most of them suffered a serious lack of climate information that would help them adapt. In Vhembe most *food producers* were relying on NGOs and extension officers for information, hence they were doing well.

It was also observed that some farmers were moving towards adaptation especially the food producers by changing their planting dates, adopting mixed cropping, intercropping and crop diversifying, but a lot (mainly subsistence farmers) have not adapted because of a general lack of knowledge, expertise and information on climate change issues. Therefore, there is need to bring awareness of the implications of climate change and to consider indigenous knowledge system-based climate change support systems and interventions to empower farmers to withstand climate change challenges.

Recommendations

The following recommendations are made:

- This study was conducted in Mopani and Vhembe district municipalities, Limpopo targeting only four local municipalities, and this limits inferring the study findings for other rural smallholder farmers. Therefore, surveys should be conducted in more rural areas.

Recommendations for policy makers

There is urgent need to encourage farmers to adopt climate-smart agriculture technologies which can be achieved through creating and enabling policy environment for adaptation. The rural smallholder farmers of Mopani and Vhembe district municipalities need to be trained on how to adapt to the negative climatic shocks, and therefore, the government need to work on providing trainings and workshops on climate change awareness in order to support local communities in dealing with the impacts of climate change, to establish irrigation schemes and provide inputs such as drought resistant crop as well as insurance policies for rural smallholder farmers. The farmers need to be trained and encouraged to adapt by employing crop rotation, intercropping, mulching, and change planting dates, crop diversification and water harvesting techniques.

There is also need to develop strategies to integrate indigenous knowledge and the scientific practices in order to provide robust climate adaptation information. Policy makers should also note that adaptation strategies to climate change effects should not only be a top-down approach, rather bottom-up approaches in decision making and implementation, especially on disseminating climate information to smallholder farmers. Therefore, it is highly recommended that the government invest in smallholder farmers so that, in the long run, these farmers graduate from just being subsistence farmers and food producers to commercial farmers. These outcomes would contribute to the achievement of the South African National Developmental Plan and Food and Nutrition Security Policy goals. Decision makers in agriculture could use information generated by this research to design new strategies towards mitigating the climatic and non-climatic shocks faced by smallholder farmers.

Training of extension officers to come to speed with climate change knowledge and mitigation strategies at the local municipality level is needed. There is also a need for in-depth studies on

how the strategies mentioned here are being implemented, how effective they are and how they can be adapted to best suit the local conditions.

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APPENDIX A: Survey Questionnaire
University of KwaZulu-Natal

Name of Interviewer	:	.....
Date	:	.....
Province	:	.....
District	:	.....
Municipality	:	.....
Farm/Village name	:	.....
Contact details	:	.....
Enumerator name	:	.....

All the information provided here will be treated as STRICTLY CONFIDENTIAL. Data gathered by this tool shall be used solely for the purpose of this intended evaluation and nothing else. Personal details and socio-economic details of respondents shall be kept confidential and no mention of names shall be made in the final report that shall be compiled.

For purposes of record, it is hereby required that consent is given by means of signing the declaration below by the respondent prior to the beginning of the application of the application.

I..... (Surname & Initials) hereby declare that I understand the purpose of the interview and grant the permission for it to be conducted with me as a respondent.

Signature .....Date .....

Section A: Socio-economic demographics

1. **Gender**

0=Male	1=Female

2. **Age:**
3. **Marital Status**

0=Single	1=Married	2=Widowed	3=Divorced

4. **Are you the household head?**

0=Yes	1=No

5. **Level of education**

0=No Formal education	1=Primary	2=Secondary	3=Tertiary

6. **Are you still in good health?**

0=Yes	1=No

7. **Total household income per month**

0=Below R800	1=R801 – R1500	2=R1501-R3500	3=Above R3500

8. **Which of the income sources is the major source of income**

0=Pension	1=Farming	2=Part-time job	3=Full-time job	4= Remittances	5=Social-grant

9. **Do you belong to any social network?**

0= Yes	1= No

10. **Which social networks do you use more frequently?**

0= Facebook	1= Twitter	2= Whatsapp

11. **Do you belong to any social group/s?**

0= Yes	1= No

12. If yes name them.....

13. Means of land ownership

0=Allocated (communal)	1=Inherited	2=Borrowed	3=Rental	4=Bought

14. How long have you been farming?

0=Less than 5yrs	1=6 to 10years	2=11 to 20years	3=Over 20 years

15. What is the total hectare of your land?

0= Less than 1 ha	1= greater than 1 and less 2.5ha	2= Greater than 2.5

16. Size of the land usually cultivated?

0= Quarter of the land	1= Half of the land	2= Total area

17. How do you perceive your land's fertility?

0= Very fertile	1= Fertile	2= Infertile	3= Don't know

18. What is the location of your land?

0= Upper land	1= Low land	2= Plain	3= River valley

19. What is the land used for in the previous year?

0= Cropped	1= Grazing	2= Fallow	3= Other

20. What is the farm produce used for from your land?

0= Home consumption	1= Sales	2= Animal feed

21. What proportion of the produce is consumed by household?

0= Quarter of produce	1= Half of the produce	2=All of the produce

22. What is the estimated proportion of produce sold?

0= Quarter of produce	1= Half of the produce	2=Sell everything	3= Don't sell

23. To whom do you sell?

0= Local People	1= Agent	2= Commercial Market	3=Other

24. If other specify ……

25. What crops do you grow at present? (Rank levels of crops grown in the second column – 1 for mostly grown crop)

Crop	**Rank**

How do you select the crop(s) to grow?

	Reason	**Rank**
1	Early maturity	
2	Resistance to disease	
3	Resistance to drought	
4	High yield potential	
5	Easy market access	
6	Easy management of crop	
7	Human consumption	
8	Other	

26. Who mainly influences your crop selection?

0= Extension officers advise	1= Farmer to farmer advise	2= NGOs advises	3= Myself	4= Indigenous Knowledge	5=Other specify

27. What is your source of water for crop irrigation?

0= Rain-fed	1= Tanks	2= Tap	3= Rain harvest	4= River	5= Dam

28. Have you ever heard about climate change?

0=Yes	1=No

30. What is your most reliable source of information on climate change?

0=Radio	1=Internet	2=TV	3=Farmer to Farmer	4=Family member	5=Extension officers

31. What major changes in weather have you observed in your community over the last 10 years?

0= Floods	1= prolonged droughts	2= very hot seasons	3= very wet seasons	4=haven't observed any changes

32. If it's a combination, please specify.....

33. What is the main impact of these changes on the local community?

0= Crop failure	1= Infrastructure	2= Livestock deaths	3= Human disease outbreak	4= Food insecurity

34. Have you experienced low crop yields over the past 10 years?

0= Yes	1= No

35. How severe has the loss been over the past 10 years?

0= Very severe	1= Moderately severe	2= Not severe

36. At what stages do you usually lose your crops?

0= Germination stage	1= Vegetation stage	2= Reproduction stage	3=Seed formation stage

37. What do you think are the causes of the yield decline?

0=Natural causes (droughts, hails, floods)	1= Pest damage	2=Disease outbreak	3= Lack of farm inputs	4= Lack of water

38. If it's a combination, please specify the causes.....

39. What support systems have you used to cope with the challenge and who provides them?

_____
_____
_____
_____
_____

40. Have you been trained on climate change interventions?

0=Yes	1=No

41. **Are there institutions/organisations that are working with you to provide climate change support?**

0=Yes	1=No

42. **If Yes please provide the institutions/organisations names and support they provide**

Institutions/organisation	**Support provided**

43. **Tick the most reliable institution/organisation that provides climate change support?**

0=Extension officers	1=Farmer organisations	2=Social groups	3=NGOs	4=Family member	5=Media

44. **Extension officers are knowledgeable about climate change support interventions**

0=strongly agree	1=agree	2=neutral	3=disagree	4=strongly disagree

45. **Extension officers are resourceful with climate change support interventions**

0=strongly agree	1=agree	2=neutral	3=disagree	4=strongly disagree

46. **List the examples of climate change interventions provided by extension** *(Rank them to order of importance)*

Examples of interventions	**Rank**

47. **The information you get from extension officers about climate change support interventions makes a difference in your crop production**

0=strongly agree	1=agree	2=neutral	3=disagree	4=strongly disagree

48. Do you have any insurance protection against floods?

0=Yes	1=No

49. Do you have any insurance protection against droughts?

0=Yes	1=No

50. Do you have any insurance protection against hot temperatures warning?

0=Yes	1=No

51. If you do not have any insurance protection how do you usually cope?

_____
_____
_____
_____
_____

52. Have you ever experience shortages of agricultural-based food items at your household?

0=Yes	1=No

53. If yes, what were the reasons for the food shortages?

0= Price increase	1= Droughts	2=Floods	3= Lack of farm inputs

54. Which months did you experience shortages of agricultural-based foods the most?

0= Dec-Feb	1= March-May	2= June-Aug	3= Sep-Nov

55. How did you cope with these shortages?

0= Eat less food	1= Change diet	2= Borrowed money	3=Received food from relatives	4= Sent older children away to work

56. Have you made any adjustment in your farming practices to climate change?

0=Yes	1=No

57. What adaptation measures have you used to deal with the changes in temperatures?

0=Crop and variety diversification	1=Changing dates of planting	2=Build water harvest scheme	3= Mixed Cropping

58. Any other specify……

59. What adaptation measures have you used to deal with the changes in rainfall?

0=Crop and variety diversification	1=Changing dates of planting	2= build water harvest scheme	3= Intercropping

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

0=Lack of information	1= Lack of inputs	2=Drought/Water shortage	3=Do not see the need	4=Poor health

61. How do you feel about dealing with climate change challenges?

0= Fearful/afraid	1= Helpless	2= Assured	3= Powerless	4= Encouraged

APPENDIX B: Focus group discussion guide

1. Describe your understanding and experience of climate change impact on your production system
2. What kind of support system do you receive with regards to your farming system?
    - *Mention them, describe their contribution&perceived impact on farming system*
    - *Rank them according to order of importance*
    - *Reliability and timeliness of receiving services/information , how do they deliver services/information*
3. Tell me about the role of various institutions/organisation that advise you about climate change support systems.
    - *Mention their names*
    - *Climate services, interventions and support they provide*
    - *How important are they to you*
    - *Describe your relationship with each provider (Using a venn diagram) also show how the identified climate interventions and support they provide*
    - *Reliability and timeliness of receiving services/information , how do they deliver services/information*
    - *How useful are they? (use a scale of 1-5 for them to indicate numerically while they justify why that particular rank)*
4. What support systems have you been using to cope with climatic and non-climaticshocks?
5. What do you think is the role of an agricultural advisor?
6. Do you think the government is doing enough to support famers on climate change challenges?
    - *What are the perceived challenges to the effective receipt and use of the climate change interventions and support systems?*
    - *If you were to advise the government what would you suggest/ communication platforms*
    - *What processes would you follow to ensure that farmers receive and use climate change interventions and support systems?*

APPENDIX C: Transect Walk

Municipality……..

Date:……..

Village……..……

- Which agricultural areas do you think have been affected by climate change, describe what you think happened and what is being done & by who? (e.g. fields, dams, rivers *etc*)
- Has your crop production system changed over years? Explain how it has changed and what influenced change?
- When affected by climate change shocks, how do you deal with it?
- Do you accept climate change info from extension officers, and do you use that information to make decision?
- Do you have your own methods of predicting changes?
- How is the government assisting and or supporting you with the challenges of climate change? Are you finding their interventions and support useful?

OBSERVATIONS

Elements under observation	**Observations**
• Farming system	
• Crop management system	
• Soil type	
• Farm size	
• Crops planted	
• Access to agricultural–based resources	**Scale:** **Poor** **Bad** **Good**

APPENDIX D: Approval letter from Limpopo Department of Agriculture (LDA)

RESTRICTED

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
AGRICULTURE AND RURAL DEVELOPMENT

Ref: 12R

Enquiries: R.R Ramugondo

01 September 2015

Ms. Nomcebo Rhulani Ubisi

University o fKwaZulu-Natal

School Of Agricultural, Earth and Environmental Sciences (SAEES)

College of Agricultural Engineering and Science

University of Kwa-Zulu-Natal

Dear Ms. N.R Ubisi

Re: Permission to conduct Research on Exploring Smallholder farmers' perceptions and adaptation strategies to Climate change in Limpopo Province, South Africa

1. The undated letter of request for permission to do research from Dr.Unathi Kolonisi has reference.
2. After listening to your presentation on 25 June 2015 on the intended Research study on **Exploring smallholder farmers' perceptions and adaptation strategies to climate change in Limpopo Province**, it was decided to grant you permission to undertake the study in the province seeing that the study may come up with some recommendations on how our small-scale farmers can improve their Food production systems in the face of Climate change.
3. Kindly take note that you will be expected to hand over a copy of your final report to the Department for record purposes as well as reporting to the Limpopo Research Forum housed in the Office of The Premier. You may also be invited to share your findings in the Research Forum
4. Hoping that you will find this in order.

Kind regards

03/09/2015

M.W. Moeng **Date**

GM- Agricultural Advisory Services

67/69 Biccard Street, POLOKWANE, 0700, Private Bag X9487, Polokwane, 0700

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