SMALLHOLDER FARMERS' PERCEPTIONS ON CLIMATE VARIABILITY IN RELATION TO CLIMATOLOGICAL EVIDENCE IN THE MOLEMOLE MUNICIPALITY (LIMPOPO PROVINCE) SOUTH AFRICA

by

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Declaration

I declare that the dissertation hereby submitted to the University of Limpopo, for the Degree of Master of Science in Geography and Environmental Studies has not previously been submitted by me for a degree at this or any other university; I declare that this is my work and that all references contained herein have been duly acknowledged.

Signature:____________________

Date: _________________

Dedication

This study is dedicated to my late father Colly Ramusi, my mother Pinkie Ramusi, my husband Manyaka Rapholo, my in-laws Mr and Mrs Makgatho and Emily Rapholo, my sister in-law Molatelo Rapholo and my three children Makgatho, Marara and Molatelo. I would like to appreciate their love, time, support and patience throughout the different steps leading to the completion of this dissertation.

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Abstract

In spite of the widespread scientific debate on the impacts of climate variability, not much is known about smallholder farmers' perceptions towards climate variability and the impacts thereof on their agricultural practices. This is especially true for smallholder farmers in Sub-Saharan Africa in general and South Africa in particular. Literature contends that an understanding of the farmers' perceptions of climate change and variability is indispensable for effective policy formulations and adaptive strategies. This current study posits that discrepancies between farmer perceptions and climatological evidence will negatively impact on farmer adaptation options and outcomes. The objectives of the study were to; (1) assess climate variability in Molemole Local Municipality, Limpopo Province, (2) investigate farmers' perceptions of climate variability, (3) compare farmers' perceptions of climate variability with climatological data and (4) appraise farmers' adaptive strategies to climate variability.

A total of 125 farmers from Botlokwa Village participated in the study. The village was selected because it is the largest village in the municipality and it comprises mainly of rural farmers that are involved in rain-fed subsistence agriculture. In addition, the village receives limited government intervention and is in close proximity to a functional climate station (Polokwane Airport Weather Station). Based on purposive sampling, focus group discussions and a three-part closed ended questionnaire was administered to the farmers. Mean annual temperature and rainfall data (30 years) was used to assess climate variability in the study area. Farmers' perceptions to climate variability was assessed using descriptive statistics based on summary counts of the responses with Statistical Package for Social Science (SPSS) program. Logistic regression analysis was used to compare differences in perception (mean responses). Comparison of farmers' perceptions of climate variability against climatological evidence was restricted to mean annual temperature and rainfall data over the past 5 – 10 years). To appraise farmers' adaptive strategies, the Adaptation Strategy Index (ASI) and the Weighted Average Index (WAI) were employed.

Farmers' perceptions of climate variability were consistent with recorded meteorological data. Based on the ASI and WAI computations, use of indigenous knowledge systems (IKS) and crop management approaches were highly important adaptation strategies while the use of insurance and subsidies were least employed by the farmers. The results from the study also showed that the age of the household head, gender, level of education, farming experience and access to information on climate variability were crucial factors in influencing the likelihood of farmers to perceive climate variability. Given the overwhelming dependence on IKS for weather forecast, and adaptation to climate variability, it is recommended that IKS take centre stage in government initiatives and policies on climate change and variability, especially for smallholder farmers in rural settings. Sensitisation on the use of technology such as cellular phones to receive weather forecast is also recommended.

Key words: perception, climate variability, indigenous knowledge, adaptation, rural setting, small holder farmers.

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CHAPTER ONE: INTRODUCTION

1.1 Background

Climate variability and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and glacial run-off (Funk et al., 2008; McCarthy et al., 2001). Despite the widespread scientific debate concerning the impacts of climate variability, not much is known about smallholder farmers' perceptions of these impacts on their agricultural practices (Funk et al., 2008). According to the Intergovernmental Panel on Climate Change (IPCC), Africa is one of the most vulnerable continents to climate change and climate variability (IPCC, 2001; 2007). The situation is further intensified by the interaction of multiple stressors (such as floods and drought), occurring at various levels, and low adaptive capacity (Boko et al., 2007). Climate variability refers to variations in the occurrence of extremes of climate on temporal and spatial scales beyond that of individual weather events (IPCC, 2001). It includes short-term events such as drought, floods, tropical storms and long-term events such as changes in temperature and rainfall patterns (Boko et al., 2007). The short-term events cause hasty disruptions which have devastating implications for agriculture and livelihoods. These disruptions appear to be increasing problems such as heat stress, lack of water at crucial times, and diseases. All these problems interact with ongoing pressures on land, soils and water resources (Legesse and Drake, 2005).

Climate variability may also be regarded as deviations in the average state of climate and irregularities (wind, temperature and precipitation extremes) on all temporal and spatial scales beyond those of individual weather events, including short term fluctuations that happen from year to year (Ogalleh et al., 2012; Ziervogel et. al., 2006). Variability in this case is an integral part of climate change in which a change in average climatic conditions is experienced through changes in the nature and frequency of particularly yearly conditions including extremes (Smit et. al., 2000; Ogalleh et. al., 2012). The impact of extreme events mainly depends on the extent of natural hazards mitigation, sustainable human development and adaptation in response to variations in climate (O'Brien et al., 2006).

According to Tupie and Visser (2013), during the past decade, a rising body of research has emerged because of increasing concerns about the impacts of climate change on the agricultural sector in Africa. Current evidence also suggests that tropical and sub-tropical countries will be vulnerable to global warming because they are already experiencing high temperatures (Benhin, 2008). According to the Food and Agricultural Organization (FAO) impacts of climate variability on smallholder farmers in Sub-Saharan Africa are further exacerbated by other developmental stressors, notably poverty, HIV/AIDS and food insecurity (FAO, 2008). Agronomic studies also predicted a sharp fall in yields for most African crops in the absence of technological change. Without adaptation, increased heat is expected to reduce crop yields (Kurukulasuriya and Mendelsohn, 2006; Tupie and Visser, 2013).

Southern Africa is exposed to climate variability because of its overdependence on rain-fed agriculture, compounded by factors such as extensive poverty and weak financial and structural capacity. This has led to overall decrease in agricultural productivity and yields, including rangeland livestock production, threatened food security and increased the risk of famine (FAO, 2008). In one of their reports, the South African National Biodiversity Institute (SANBI, 2013) based on the Long-Term Adaptation Scenarios (LTAS) project, suggested that Limpopo Province could face a potential increase in temperature by as much as 2°C by 2035, by 1-2°C between 2040 and 2060, and by 3-6°C between 2080 and 2100 (accompanied by a decreased rainfall in the long term). Limpopo is the breadbasket and agricultural engine of South Africa, accounting for nearly 60% of all fruit, vegetables, maize, wheat, and cotton (GoLimpopo, 2015). An estimated 33% of households in Limpopo are considered agricultural households, and the province is home to 16% of South Africa's agricultural households (StatsSA, 2013).

In view of the aforementioned challenges, developing context specific adaptation strategies to climate variability is widely acknowledged as a vital component of any mitigation measure (IPCC, 2007; Milder et al., 2011). However, Milder et al. (2011) also pointed out that ineffective adaptation to climate variability will still push rural farmers on a thin edge of survival (Adams et al., 1998; FAO, 2008). Where adaptation strategies are effective, farmers can reach their food security, sustain income and livelihood objectives even in the face of climate variability (Boko et al., 2007; Gwimbi, 2009). Adaptation is the most efficient and friendly way for farmers to reduce the negative impacts of climate change (Füssel et al., 2006). This can be done by the smallholder farmers themselves taking adaptive actions in response to climate variability or by governments implementing policies aimed at promoting appropriate and effective adaptation measures. Bryant et al. (2008) and Moyo et al. (2012) equally concur that farmers' perceptions towards climate variability are important in adaptation as they determine decisions in agricultural planning and management.

On the contrary unlike their commercial counterparts, smallholder farmers struggle to adapt to climate change and variability 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) emphasised 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) also stated that smallholder farmers in semi-arid areas practice mainly rain-fed farming and have little access to irrigation facilities.

Despite the benefits of effective adaptation strategies to climate variability, the aforementioned challenges tends to compromise the likelihood of any envisaged success (Ofuoku, 2011). Against this backdrop, this study seeks to provide insights on smallholder farmers' perceptions on climate variability in relation to climatological evidence in Botlokwa Village, Molemole Local Municipality of Limpopo Province in order to identify best practice and/or make recommendations thereof.

1.2 Statement of the problem

Most smallholder farmers in sub-Saharan Africa depend on rain-fed agriculture for their livelihoods (Moyo et al., 2012; Shiferwa et al., 2014; Kihupi et al., 2015). However, they are often afflicted by the vagaries of weather and climate, most notably temperature and rainfall (Moyo et al., 2012; Shiferwa et al., 2014; Kihupi et al., 2015). Past trends for Southern Africa have suggested that the sub-region will experience increases in temperature and declining rainfall patterns as well as increased frequency of extreme climate events such as droughts and floods in future (Moyo et al., 2012). For smallholder farmers in South Africa in particular and the sub-region in general, variability and unpredictability of climate is a major challenge which poses a risk that can critically restrict options and limit their development (Shiferwa et al., 2014; Kihupi et al., 2015). Such sensitivity to climatic variations and extremes are further compounded by economic, social, geographical, cultural, institutional, governance and environmental factors (Maponya and Mpandeli, 2012; Rakgase and Norris, 2014). Maponya and Mpandeli (2012) further asserted that vulnerability to climate extremes varies across temporal and spatial scales, with resource-poor farmers in rural areas often the worst hit. For this category of farmers, their perception towards climate change and variability is central to effective mitigation and management of potential hazards (Debela et al., 2015).

Botlokwa Village in the Molemole Municipality in Limpopo Province represents a cohort of rural smallholder farmers who are exposed to significant drought risk. A number of studies have been conducted in the area, notably on: the extent of drought risk (Mpandeli and Maponya, 2013a; Mpandeli and Maponya, 2013b), impact of climate variability on agricultural (crop) yield (Mpandeli and Maponya, 2013b; Tshiala and Olwoch, 2013) , farmers adaptation strategies (Debela et al., 2015) and factors influencing choice of coping strategies (Maponya and Mpandeli, 2012), however studies on smallholder farmers' perceptions on climate variability in relation to climatological evidence have not been conducted. This current study posits that discrepancies between farmer perceptions and climatological evidence will negatively impact on farmer adaptation options and outcomes.

1.3 Motivation

Rain-fed agriculture is the main source of livelihood for rural communities in the Botlokwa Village. However, from my observation (through preliminary interactions with the farmers), the rural farmers indicated that they have very limited access to governmental interventions (such as drought relief programs, information on drought early warning systems, and climate forecast) as such rely on their perceptions towards climate change and variability to develop adaptive strategies. Despite current adaptive strategies, the farmers acknowledge that significant climate-related challenges persist. According to Debela et al. (2015), perception strongly affects how farmers deal with climate induced risks and opportunities, and the precise nature of their behavioural responses to this perception will shape adaptation options, the process involved and adaptation outcomes. However, perceptions may be influenced by farmer's knowledge and belief systems (Kihupi et al., 2015). Misconception about climate variability and its associated risk will result in maladaptation, which may further compound the problem. Thus, for adaptation strategies to be sustainable in Botlokwa Village, the rural smallholder farmer's perceptions need to be appraised. Where differences in perceptions and climatological data are evident, appropriate intervention measures (education, skill development, material and financial support) will be identified and recommendations made for implementation.

1.4 Aims and objectives

1.4.1 Aims

The aim of this study is to assess smallholder farmers' perceptions on climate variability in relation to climatological evidence in Botlokwa Village, Molemole Local Municipality in Limpopo Province.

1.4.2 Objectives

The objectives of the study are to:

- Assess climate variability in Molemole Local Municipality.
- Investigate farmers' perceptions of climate variability.
- Compare farmers' perceptions of climate variability with climatological data.
- Appraise farmers' adaptive strategies to climate variability

1.5 Significance of the study

It is anticipated that findings from this study will;

- Contribute towards a broad understanding of climate-related challenges on local communities in developing countries, whose major source of livelihoods is smallholder rain-fed agriculture.

- Shed more light on the implications of smallholder farmer's perception on adaptive strategies in Molemole Municipality and other communities with identical characteristics.

- Contribute towards policy formulation. It will help policy makers identify the management practices that are available and effective in adapting to climate variability.

- Complement the knowledge of the agricultural extension officers and other stake holders in order for them to assist the smallholder farmers understand climate variability, climate variability impacts and adaptation measures being implemented.

1.6 Operational definitions

- Adaptation: Refers to the changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change (IPCC, 2001).

- Crop yield: It is the measurement often used for a cereal, grain or legume and is normally measured in metric tons per hectare (or kilograms per hectare).

- Food security: As defined by FAO (Food and Agriculture Organisation, 2008), refers to a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

- Rainfed agriculture: A form of agriculture that is wholly dependent on rainwater for irrigation.

- Smallholder farmer: Those farmers owning small-based plots of land on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour (NDA, 2012).

1.7 Organisation of the study

The dissertation 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 variability and its impacts on rural livelihoods of smallholder farmers, as well as the perceptions of smallholder farmers on climate variability, their adaption strategies and available climate variability interventions and support systems.

- Chapter 3 presents the description of the study area, and the methodology used to collect and analyse data.

- Chapter 4 presents results and discussions deduced from the analysis carried out in chapter 3.

- Chapter 5 presents the conclusions and recommendations.

1.8 Conclussion

As deducted from the background and the problem statement, the aim of this study will be to assess smallholder farmers' perceptions on climate variability in relation to climatological evidence in Botlokwa Village and the objectives laid out are to be dealt with in various chapters.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews information on climate variability from a global level to a regional level. Such a review includes literature on the impacts of climate variability on agriculture, a review of literature on the relationship between climate variability and food security, the importance of perceptions of small holder farmers to climate variability, factors affecting farmers' perceptions, comparing farmers' perceptions on climate variability to meteorological data, importance of perceptions; perceptions of smallholder farmers to climate variability, coping and adaptive strategies and the relationship between farmers' perceptions, coping and adaptation strategies

2.2 Background to climate variability

2.2.1 Climate change versus climate variability

Climate change is inevitably resulting in changes in climate variability and in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events (IPCC, 2012). Changes in climate variability and extremes can be visualized in relation to changes in probability distributions, (IPCC, 2012). Climate variability already has substantial impacts on biological systems and on the smallholders, communities and countries which depend on them. Climatic variability can be considered as a component of climate change. According to the IPCC climatic variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, to name a few.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Climate variability refers to changes in climatic patterns, such as rainfall, weather and climatic patterns (Ngaira, 2007). It is the variation around the average climate, including seasonal variations in atmospheric and ocean circulation such as the El Nino. According to Orindi and Murray (2005), climate variability is the shift from the normal experienced rainfall pattern of seasons to abnormal rainfall pattern.

Climate is a primary determinant of agricultural productivity and it influences the types of vegetation that can grow in each location. In this context, agriculture is complex, involving different driving parameters (such as physical, environmental, economic and social). It is acknowledged that crop production is very sensitive to climate change (McCarthy et al., 2001), with different effects according to specific regions. Studies on climate change impact shows that there is an overall reduction of potential crop yields and a decrease in water availability for agriculture and population in many parts of the developing world (IPCC, 2001).

There is a biophysical effect on crop production by the change in meteorological variables, including rising temperatures, fluctuating precipitation regimes and increasing levels of atmospheric carbon dioxide (McCarthy et al., 2001). Biophysical effects of climate change on agricultural production depend on the region as well as the agricultural system, and the effects vary over time (Adams, 1998).

El Nino-Southern Oscillation (ENSO) is the most studied occurrence of climate variability. ENSO is a contact between the ocean and the atmosphere over the Pacific Ocean that has significant consequences for weather patterns around the globe (IPCC, 2001). Since the early 1990’s drought in southern Africa, awareness of the potential to manage climate variability has grown. This has been facilitated through seasonal climate forecasting and monitoring of ENSO. Nevertheless, ENSO is not the only factor affecting southern Africa’s weather patterns (Dilley, 1999). Recent evidence has shown that there is now an escalation in drought frequency predominantly in the semi-arid regions. In some years, the same locations that experience droughts are experiencing flooding. This has undesirably affected smallholder farm production. Also, the rainfall season in the past decade has unusually started late and farmers are increasingly wary of instituting the effective planting period (Jennings and Magrath, 2009).

Erratic patterns of rainfall with high frequencies and severities in floods and droughts have also been experienced since 1980 (NASA, 2011). Figure 2.1 shows the global mean land-ocean temperature index, from year 1880 to 2000, with the base period 1951-1980. The black line is the annual mean and the red line is the five-year running mean. The green bars show uncertainty estimates.

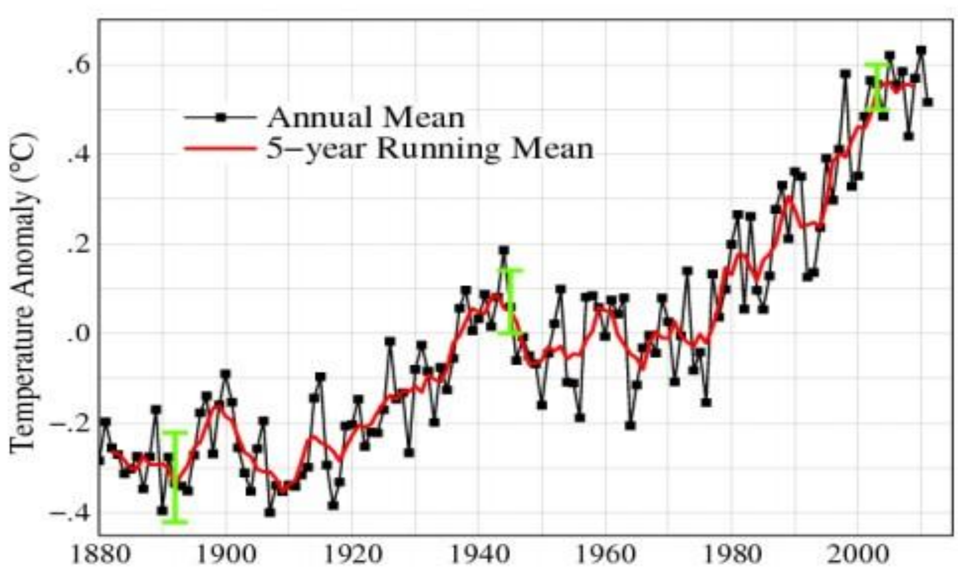


Figure 2.1. Global Land-Oceanic Temperature Index (NASA, 2011)

2.2.2 Climate variability and change in Southern Africa

Statistical evidence suggests that South Africa has been getting hotter over the past four decades, with average yearly temperatures increasing by 0.13°C a decade between 1960 and 2003, with relatively higher levels for the fall, winter and summer periods (Benhim, 2006). There has also been an increase in the number of warmer days and a decrease in the number of cooler days (Benhim, 2006). Moreover, the average rainfall in the country is very low, estimated at 450mm per year – well below the world's average of 860mm per year – while evaporation is comparatively high. In addition, surface and underground water are very limited, with more than 50% of the available water resources being used for only 10% of the country's agricultural activities (Benhim, 2006).

South Africa's climate is generally warm, with sunny days and cool nights. Rainfall mostly occurs in the summer (November to March), with winter rainfall (June to August) in the south-west around the Cape. Temperatures are more influenced by variations in elevation, terrain and ocean currents than latitudes (Figure 2.2). For example, the average annual temperature in Cape Town is 17°C and in Pretoria 17.5°C, although these cities are separated by almost ten degrees of latitude (Palmer and Ainslie 2002). The climatic conditions contrast in response to the movement of the high-pressure belt that circles the globe between 25° and 30° south latitude during the winter and low-pressure systems that occur during the summer.

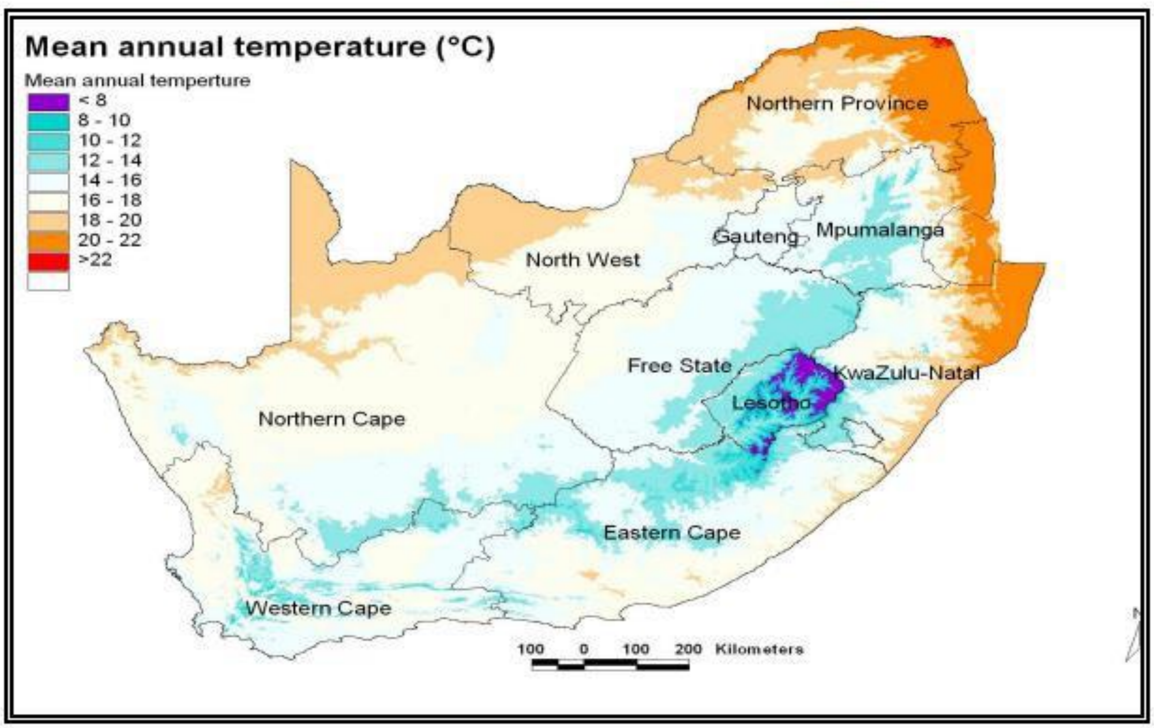


Figure 2.1. Distribution of mean annual temperature in South Africa (Durand, 2005).

There is very little variation in average temperatures from the south to north, but they vary noticeably between east and west, largely in response to the warm Agulhas ocean current, which sweeps southward along the Indian Ocean coastline in the east for several months of the year, and the cold Benguela current, which sweeps northward along the Atlantic Ocean coastline in the west. Air temperatures in Durban, on the Indian Ocean, average nearly 6°C warmer than temperatures in the same latitude on the Atlantic Ocean Coast. The effects of these two currents can be seen even at the narrow peninsula of the Cape of Good Hope, where water temperatures average 4°C higher on the east side than on the west. Summer temperatures on average vary across the country between 20°C and 38°C, with high levels occurring in the far north. The highest maximum summer temperature (48°C) has been recorded in the Northern Cape and Mpumalanga Provinces. Winter temperatures range between 6°C and 20°C, with a record minimum (-6.1°C) occurring in north-west Cape Town.

Record snowfalls (almost 50cm in June 1994) have also been experienced in the mountainous areas bordering the Kingdom of Lesotho. As noted above, temperatures are strongly determined by elevation and distance from the sea (Figure 2.3). The high inland regions (1500–1700m) experience warm summers (26–28°C) and cool winters (0–2°C), frost during the coolest months and occasional snowfalls (NDA, 2001a; Schulze, 1997).

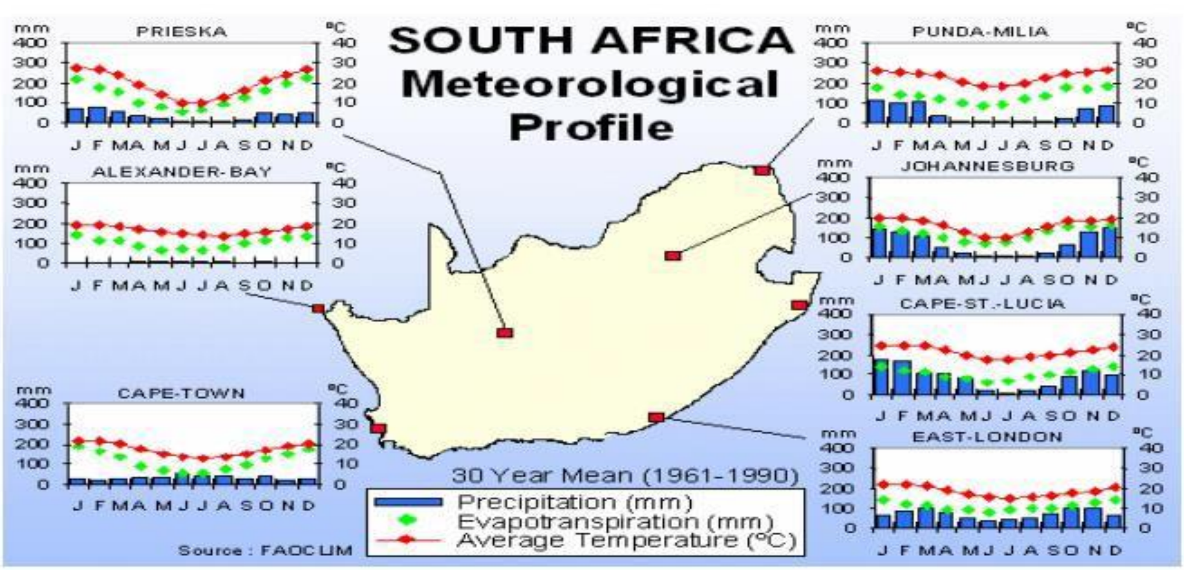


Figure 2.2. South Africa’s meteorological profile (FAO, 2001).

The northern parts of the coastal zone experience warm winters (8–10°C) and warm summers (32°C). The vast interior (mostly the Kalahari basin and the Nama-Karoo) experiences more extremes of climate, with very cool winters (0–2°C) and very warm summers (32–34°C). The low-lying eastern coastal belt, with Durban in the KwaZulu-Natal Province as the centre, is hot and humid during summer. The southern and south-western coastal zone experiences moderate winters (6–8°C). The mean daily minimum temperature on the west coast in July is 6–8°C, but there is little or no frost (Palmer & Ainslie, 2002; NDA, 2001a).

There is a wide regional variation in annual rainfall (Figure 2.4) and the rainfall decreases from east to west, from over 1000mm in the east to less than 100mm in the Namib and Namaqualand desert regions. A 500mm rainfall line divides the country into two main

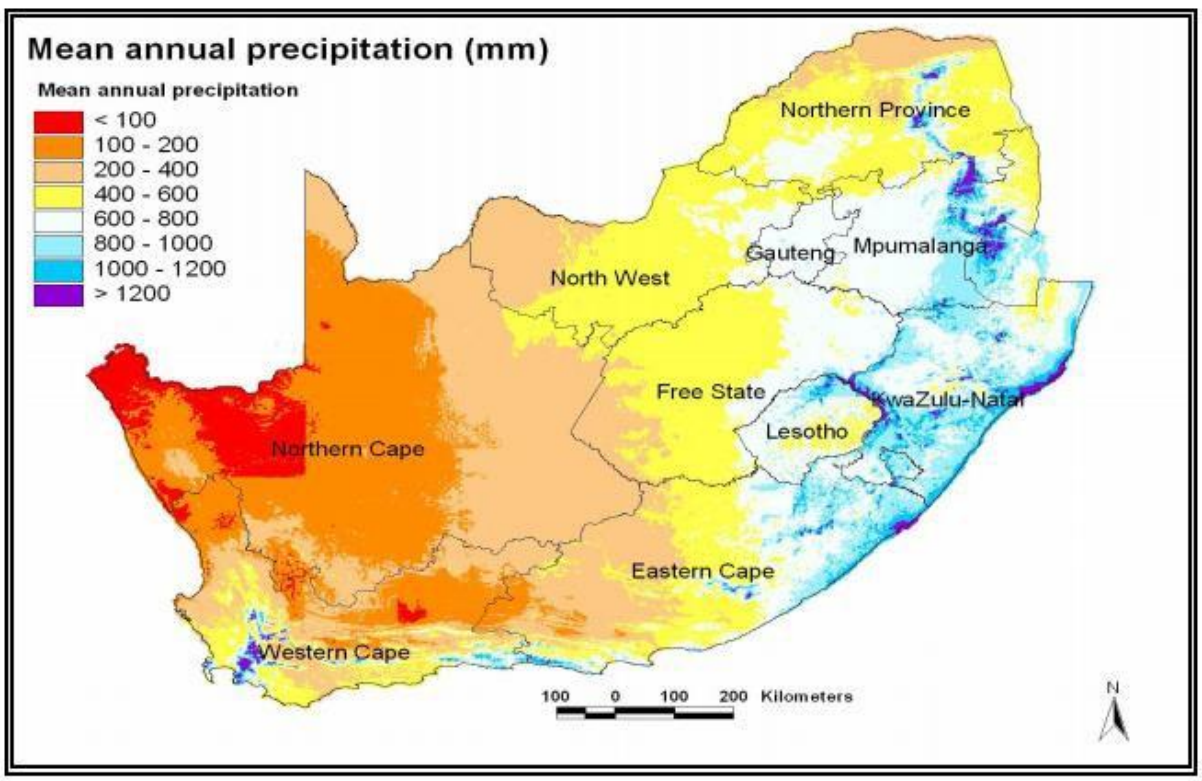


Figure 2.3. Distribution of mean annual precipitation (mm) in South Africa (Durand, 2005).

sections, with the land east of the rainfall line generally suitable for growing crops and the land west of the rainfall line mainly for livestock grazing or crop cultivation on irrigated land (NDA, 2001b). Three main rainfall regions can however, be identified in the country:

(i) The winter rainfall region in the south-western Cape with less than 500mm per year;

(ii) the area with rainfall throughout the year along the southern coastal region, with more than 700mm per year and;

(iii) the summer rainfall area in the rest of the country (approximately 86%) with rainfall between 500mm and 700mm per year.

Given the temperatures and rainfall patterns, two main farming seasons are identified in the country: (i) the summer season from October/November to March/April and (ii) the winter season from April/May to August/September. The various farming activities are influenced not only by climate conditions but also by the different vegetation and soils

Figure 2.5 shows that temperature levels over most of the 1961–1989 eras were above the average of 17.5°C, and were significantly higher after the 1980s. Rainfall levels were very variable, but indicated a falling trend between the mid-1970s, and early 1980s after which they tended to increase again. Droughts occurred in 1982/83, 1991/92 and 2003/2004 farming seasons.

Kruger and Shongwe (2004) analysed climate data from 26 weather stations across the country. Of these, 23 showed that the average annual maximum temperature had increased, in 13 of them significantly. Average annual minimum temperatures also showed an increase, of which 18 were significant. In general, their analysis indicates that the country’s average yearly temperatures increased by 0.13°C per decade between 1960 and 2003, with varying increases across the seasons: fall 0.21°C, winter 0.13°C, spring 0.08°C and summer 0.12°C. There was also an increase in the number of warmer days and a decrease in the number of cooler days.

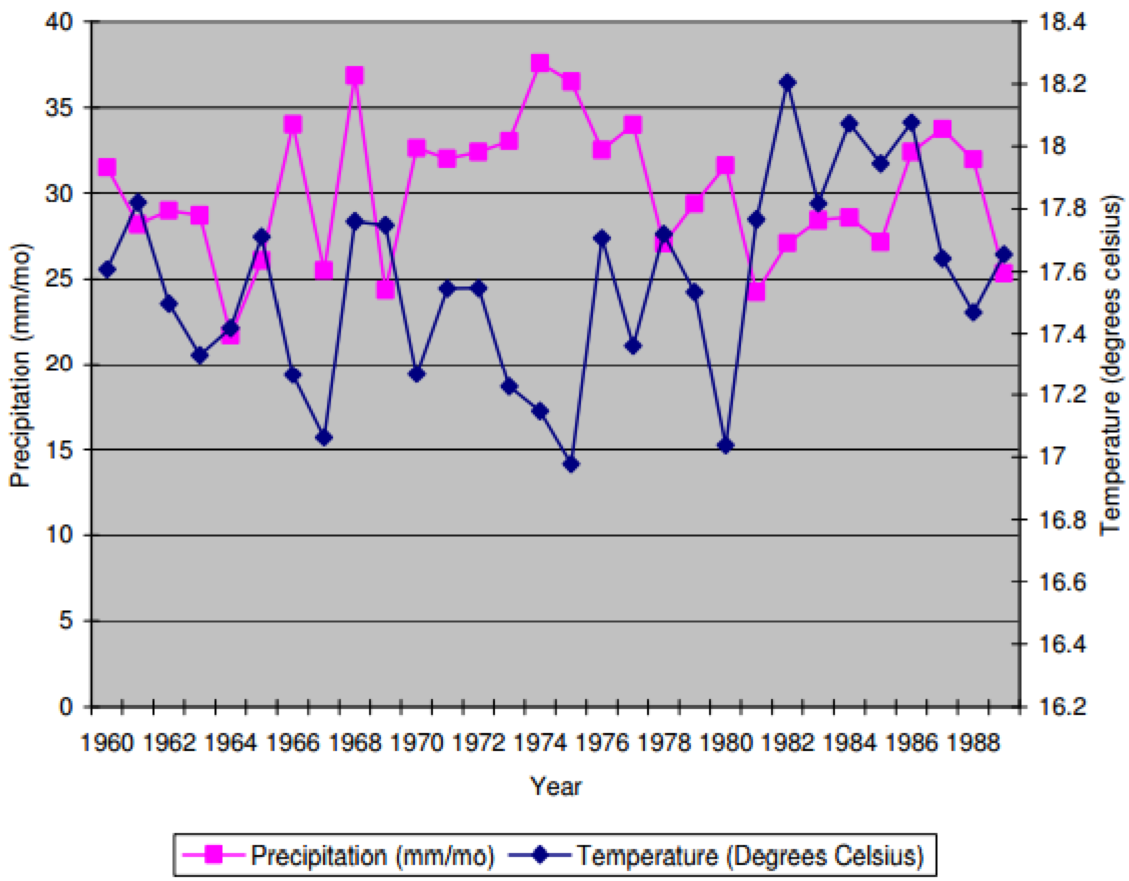


Figure 2.4. Distribution of mean annual precipitation and temperature in South Africa (Benhim, 2006)

On the geographical locality of our study area, Limpopo Province is situated in the northern part of South Africa, which is a tropical region. According to Mendelsohn and Dinar (1999), tropical regions in the developing world are predominantly vulnerable to potential damage from environmental changes due to large areas of these regions that are covered by poor soils, which have already made much of the land unusable for agriculture. Small-scale farmers in the Province, who have little capital, will not be able to come up with new strategies that will be required to adapt to the change in climate. These variations in temperature, together with the already scarce water resources in the country are expected to have a significant effect on all sectors of the economy, including agriculture (Benhim, 2006).

According to Benhim's (2006) study, agriculture is expected to be most affected by these changes because it is highly dependent on climate variables such as temperature and precipitation, and also because of:

(i) the semi-arid nature of the country with increased farming on marginal lands,

(ii) the frequency of droughts, and

(iii) the scarcity of water, which is exacerbated by a high spatial variability of rainfall.

2.3 Impacts of climate variability on agriculture

The agricultural sector is seen as an important source of livelihood for the Limpopo province especially those in rural areas, but with extreme weather like drought, it is going to be very difficult for people to survive. It is quite disturbing that in some parts of the province, farmers are already forced to sell their livestock because of drought conditions. This places a serious challenge for agriculture and results in food scarcity not only in the province but South Africa as a whole. According to Makhura (2001), a sharp decline in agricultural production would not only have implications for a province or country but also for the region as a whole.

According to the recent IPCC reports (IPCC, 2013, Niang et al., 2014), there has been an increase in observed temperature trends by 0.5°C or more over most parts of Africa during the last 50 – 100 years (Grab and Craparo, 2011; Hoffman et al., 2011; Mohamed, 2011; Stern et al. 2011; Funk et al., 2012; Nicholson et al., 2013). Similarly, the mean temperature increase over the African continent is projected to exceed 2°C towards the end of the 21st Century (e.g. Christensen et al., 2007; Joshi et al. 2011; Sanderson et al., 2011; James & Washington, 2013). The IPCC's fourth assessment report indicated that smallholder and subsistent farmers, pastoralists and artisan fisher folk will suffer complex, localised impacts of climate change (IPCC, 2013). They face an increasingly complex set of challenges that make them more vulnerable than ever to changes that are beyond their control (Boko et al., 2007).

Extreme climatic conditions and high seasonal variability of climatic parameters could negatively affect productivity (Li et al., 2006) because rainfall guides the crop yields and determines the choice of the crops that can be grown. The analysis of rainfall records for long periods provides information about rainfall patterns and variability (Mzezewa et al., 2010). Drought mitigation can be premeditated by understanding daily rainfall behaviour (Mzezewa et al., 2010). Dry spell analysis contributes to the estimation of the probability of intra-season drought and management practices can be adjusted accordingly (Mzezewa et al., 2010). It is of importance to know how long a wet spell is likely to persist, and what the probabilities are of experiencing dry spells of various durations at critical times during the growing season (Mzezewa et al., 2010).

Drought is a serious problem in the province because the province is in a semi-arid area with low, unreliable rainfall. The impact of lower rainfall has negative effects on the agricultural sector, low rainfall resulting in decreases in agricultural activities, loss of livestock, shortage of drinking water, low yields and shortage of seeds for subsequent cultivation (Phokela and Mpandeli, 2012). Limpopo province is prone to drought and faces challenges of drought from time to time. As a result of the severe drought, the province experienced reduced grazing and water for livestock and irrigation which negatively impacted the agricultural sector (Phokela and Mpandeli, 2012). The most important factor limiting agricultural production in South Africa is the availability of water. Rainfall is distributed unevenly across the country, with humid, subtropical conditions in the east and dry, desert conditions in the west (Benhim, 2006). The country's average annual rainfall is 450mm per year, well below the world's average of 860mm, while evaporation is comparatively high (DWAF 2004). Only 10% of the country receives an annual precipitation of more than 750mm and more than 50% of South Africa's water resource is used for agricultural purposes. Both commercial farming and especially subsistence farming may be affected by less availability of water owing to adverse climate change (Benhim, 2006). This is expected to vary across the different agro-climatic zones, provinces and different agricultural systems in the country.

Climate variability and change is devastating for East African countries such as Ethiopia and Kenya, where smallholder farmers depend on rainfed agriculture. In 2011, for example, the worst drought in 60 years affected millions of people in Somalia, Ethiopia, and Kenya, causing widespread hunger (Bishaw et al. 2013).The agricultural sector in these areas is vulnerable to adversities of weather, not only because farmers depend on rain, but also because farming is subsistence and is practiced with basic technologies on small pieces of land (Bishaw et al. 2013). These smallholder farmers thus already operate under pressure from food insecurity, increased poverty, and water scarcity (CEEPA 2006).

According to the Limpopo Climate Adaptation Strategy Report (2013), nationwide survey of farmers in South Africa indicates that several farmers have already, to varying degrees, considered and even adopted adaptation measures in response to increased climate variability. These include adjustments in farming operations (changing planting dates; adopting shorter planting periods; delaying the start of the planting period; increased use of modern machinery; collection of rainwater; increased use of irrigation; using more water-efficient crop varieties; using early-maturing varieties; and mixed farming with more livestock), increased application of chemical fertilizers and pesticides, improved water management practices, and increasing the use of shade and shelter (Benhin, 2006).

Impacts from climate variability, such a drought, are already a problem for livelihoods in Limpopo and are likely to become more pronounced with climate change. For instance, one study found that food security in Limpopo is negatively impacted by drought, resulting in food scarcity, and that farmers have already had to sell their livestock to cope with reduced availability and higher prices of livestock feed during drought (Phokela and Mpandeli, 2012).

A study by Du Toit et al (2002), showed that in the dry western areas of South Africa, crop production will become more marginal, while in the high potential eastern areas there may be a slight increase. The focus of this study is commercial farming. However, the riskier sector is subsistence farming, as these farmers have very little ability to adapt. This study does not focus on the extent of adaptation – an analysis that incorporated subsistence farming might predict worse effects of climate change on agriculture in South Africa than these authors do (Benhim, 2015).

2.4 Relationship between climate variability and food security

According to Badolo and Kinda (2014), food security is a multidimensional and flexible concept that gained prominence since the World Food Conference in 1974. Many definitions have been put forward (Maxwell 1996). They have shifted from food production and importing capabilities at the macro-level towards a focus on individuals and their ability to avoid hunger and under nutrition (Badolo and Kinda, 2014). Tweeten (1997) emphasizes that the concept of food security has three essential dimensions:

- The first dimension is food availability, which refers to the supply of foodstuffs in a country from production or imports.

- The second dimension is food access, which refers to the ability to acquire food for consumption through purchase, production or public assistance.

- The third dimension is food utilization, which concerns the physical use of food derived from human distribution.

There are several channels through which climatic variability is likely to affect food security in developing countries. To elucidate these channels, Badolo and Kinda (2014). reflect on the effect of climatic shocks on each approach (Figure 2.6).

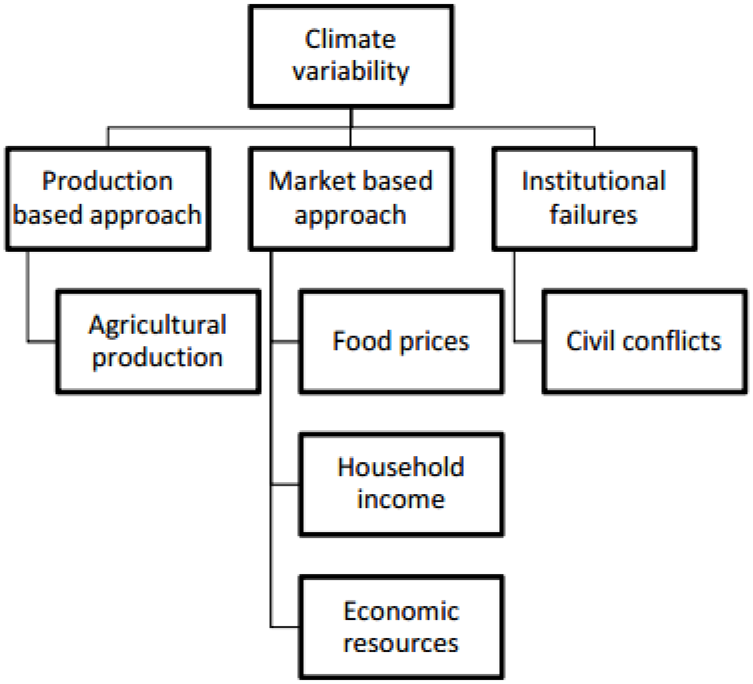


Figure 2.5. Relationship between climatic variability and food security (Badolo and Kinda, 2014).

2.5 Importance of perceptions of smallholder farmers to climate variability

Environmental perception is how we seek to understand environmental phenomena in order to attain better use of environmental resources and a more effective response to environmental threats. The processes by which we arrive at these understandings include the direct experience of the environment and indirect information from other people, science, and the media. The focus of a perception approach to environmental management is to analyse decision-making and choice of adjustment from the inside-out, or from the perspective of the decision-frame (that is, the decision and its context) as it appears to the decision-maker, with all its imperfections (Lawrence, 2002). Research has shown that choices are made within the framework of perceived alternatives and available information. Alternatives and information are profoundly affected by people's attitudes and values and the roles they play in relation to the decision to be made (Lawrence, 2002).

The major problem in adopting a perception approach is not so much in finding appropriate techniques to measure specific variables, but in knowing what variables to measure (Lawrence, 2002). According to Lorenzoni and Pidgeon (2006), people are not likely to support initiatives addressing climate change unless they consider the issue a very serious problem for society, or one that affects them personally. They further describe how people perceive events that pose a potential risk to us is captured in the issue of risk perception. This can be defined as the perceived likelihood of negative consequences to oneself and the society from the specific (environmental) phenomenon (risk) for instance climate change.

A major issue surrounding perception studies in climate change research is methodology (Falaki et al., 2013). Previous researches have focussed on analysing perception as dependent variables that were analysed separately using either descriptive statistics, probit or logit model (Falaki et al., 2013). Social scientists have found that public risk perceptions strongly influence the way people respond to hazards. Public perception is critical because it is a key component of the socio-political context within which policy makers operate and it can fundamentally compel or constrain political, economic and social action to address particular risks (Falaki et al., 2013). Human responses to environmental issues have been broadly categorised as cognitive (related to knowledge and understanding), affective (related to feelings, attitudes, and emotions), behavioural (related to changes in behaviour of the viewer), and physiological (biological or physical effects on the observer's body) (Falaki et al., 2013).

There is significant body of literature on public perceptions and awareness of climate change and variability particularly in developed countries of Europe and America, especially from 2007 (Lorenzeni et al 2007). Results of some of such studies show that awareness levels and people's perception of climate change have been rising over the past two decades, with a sharp increase from 2003 (Lorenzeni et al 2007).

Review of literature shows that the donor community, international development agencies, regional political bodies, Non-Governmental Organisations (NGOs), farmers' organisations and government involved in adaptation strategies promotion have often not taken into account perceptions of smallholder farmers of climate change (CFU, 2006; FAO, 2009, 2011b). Smithers and Smit (2009) argue that environmental perceptions are among key elements influencing adoption of adaptation strategies. This type of evidence has led to interest in how farmers understand and perceive climatic processes (Adger et al., 2005; Conway et al., 2005; Ziervogel et al., 2006). One’s perception depends on one’s environment and its characteristics and a range of beliefs, judgments and attitudes (Slegers, 2008). Experience is another important factor that shapes an individual’s perceptions, with previous experiences of poor seasons creating memories that may determine how farmers describe different types of seasons (Slegers 2008).

In his research, Weber (2010) believes that most farmers’ knowledge and exposure to climate change has been influenced indirectly by the media from events occurring in distant areas. Perception has been described as referring to a range of beliefs, judgments and attitudes (Slegers, 2008). Perception of climate variability is based on the economic and social impact it has on personal lives; and the farmers’ perceptions of climate variability are important in adaptation as they determine decisions in agricultural planning and management (Slegers, 2008).Perception is the way smallholder farmers think and behave in relation to climate variability and change (Wehbe et al., 2006). An assessment of the community perception of climate variability induced hazards can help to uncover the nature of the risk and its underlying factors and associated socio-economic consequences.

Rawat (2010) conducted a study on awareness about environmental issues and perceptions on climate change in Garhwal Himalaya region, Kunjapuri hills. The study showed mixed responses on the awareness about environmental issues. About 50 percent of the participants were confused about environmental issues but they perceived a change in climate due increased temperatures. Also, a majority perceived changes in temperature, erratic precipitation, and exhaustion of natural resources which had been taking place for the past 3 to 4 years. Almost 100% of the respondents agreed to the change in cropping patterns and animal keeping for the past 4 to 5 years. Unfortunately, the respondents in the village could not afford to adapt to climate change because they had little resources and expertise to adapt.

A similar study was conducted by Bhushal (2009) in Nepal. The study revealed that 92 percent of the farmers perceived long-term changes in temperatures of which 90 percent observed an increase in temperatures. The increase in temperatures was in line with statistical record of temperature data for the period between 1978 and 2007, which showed increasing trends, especially in winter. Even though they observed irregular climatic conditions such as malfunctioning of the ecosystem and biological system, they were not aware of climate change and variability. Instead, they had indigenous coping strategies as they managed forests well and diversified crops to limit risks. Although local people of Nepal had coping strategies, knowledge and awareness of climate change was a major challenge.

Another study was conducted by Brondizio and Moran (2008) in the Amazon, and the study showed a different aspect about perceptions on climate change and variability. The study focussed on processes that mediated perceptions of climate change and variability, and behavioural responses at individual and local level. The study discovered that most of the farmers did not remember extended drought periods and the 1997/1998 El Nino-Southern Oscillations (ENSO). As a result, most of them did not change their land use behaviours in the face of the strongest 1997/1998 ENSO.

Although farmers paid attention to climate information provided by the media, as mentioned by over 40% of farmers interviewed, the scale of information did not motivate changes in local farming behaviour. Less than 5% of farmers reported to have received information about the 1997/1998 ENSO event. The rest relied on personal experiences and good neighbourhoods to get information. Farmers highlighted poor infrastructure and limited access to credit and technology as their main problems. The only practice they adopted was information sharing among them and to agree on when and where to burn the veld, delay planting times and add firebreaks as a way of adapting to climate change.

2.6 Factors affecting farmers' perceptions of climate change and variability

2.6.1 Technology

A more important factor of varied farmers' responses is the difference between farmers in terms of personal managerial and entrepreneurial capacities and family circumstances (Gbetibouo, 2009). Farmers can again be influenced by their peers' perceptions and by values present in their communities as well as their professional associations (Gbetibouo, 2009). Adoption of agricultural technologies in agriculture is considered to be equal with the adaptation strategies that farmers undertake in the fight against the adverse effects of climate change (Nhemachena and Hassan, 2007) and as a result, adopted literature can be applied in studies regarding climate change adaptation. Studies on agricultural technology adoption by Gbetibouo (2009) observed that there is no consensus in the literature as to the exact effect of age in the adoption of farming technologies because the age effect is generally location or technology specific and hence, an empirical question.

Some studies examined factors affecting farmers' perceptions of climate change, but not the determinants of the consistency of farmers' perceptions with actual climate trends. Deressa et al. (2011) found that social networks influenced farmers' perceptions of climate change.

2.6.2 Age

According to Ndambiri et al. (2013), age may have a negative effect on the decision to adopt new farming technologies simply because older farmers may be more risk-averse and therefore, less likely to be flexible than younger farmers. On the other hand, age may have a positive effect on the decision of the farmer to adopt because older farmers may have more experience in farming and therefore, better able to assess the features of a new farming technology than the younger farmers (Ndambiri et al., 2013). Relative to gender, Asfaw and Admassie (2004) noted that households headed by males have a higher probability of getting information about new farming technologies and also undertake riskier ventures than female headed households. A similar observation is made by Tenge and Hella (2004) who point out that female headed households are less likely to adopt soil and water conservation measures since women may have restricted access to information, land, and other resources due to traditional social barriers. The age of a subsistence farmer is closely related to farming experience and their accumulated knowledge of the environment including changes in climatic conditions (Patt and Schröter, 2008; Deressa et al. 2011; Juana et al. 2013) that may go back many decades.

2.6.3 Education

Studies conducted in African smallholder farming systems have indicated that the level of formal education attained by farmers influences their ability to perceive climate change and its impact to (Ndambiri et al., 2013). Regarding education levels Ndambiri et al. (2013), observed a positive relationship between the education level of the household head and the adoption level of improved technologies and climate variation adaptation. Therefore, farmers with higher levels of education are more likely to perceive climate variability and adapt better. A related study by Maddison (2006), Nhemachena and Hassan (2007) indicated that farming experience, just like farmers' education level, increases the probability of uptake of adaptation measures to climate change.

2.6.4 Household size

When focusing of household size, a study by Croppenstedt et al. (2003) argued that larger households have a larger pool of labour and are more likely to adopt agricultural technologies than smaller households. In his study, Yirga (2007) noted that the size of the household influences individuals' adaptation to climate change in two perspectives. Different household and farm related factors influence whether and to what extent farmers perceive climate change and its impact on local agriculture (Deressa et al. 2011). Households with many members are more likely to engage in non-farm income generating activities because non-farm income buffers financial losses from farming, the householders are less likely to perceive climate change (Ndambiri et al. 2012). Access to support services such as extension services and climate information is purported to increase farmer perception of climate change and its associated risks (Maddison, 2007).

Households with large families may be forced to turn away part of the labour force from farm to off-farm activities in an attempt to earn some income that can ease the consumption pressure imposed by a large family faced by climate change (Ndambiri et al., 2013). In the second perspective, households with a large family size are considered to have a larger pool of cheap labour resource, which can readily be employed on the farm for crop and/or livestock production, unlike families with smaller household size (Ndambiri et al., 2013).

2.6.5 Awareness

In their respective studies, Maddison (2006) and Nhemachena and Hassan (2007) observed that the awareness by farmers of climate change attributes - whether precipitation or temperature or both, is of essence in as far as their adaptation decision-making process is concerned. According to Ndambiri et al., (2013), it was therefore expected farmers with access to climate change information were more likely to identify changes in climate and were therefore more likely to adapt than those without access to climate change information.

2.6.6 Livestock ownership and herd size

Livestock ownership and herd size in traditional farming systems are two related variables which have been used to represent the level of a farmer's dependence on natural resources such as pasture and water for extensive livestock production (Kemausuor et al. 2011; Legesse et al. 2013). The availability of such natural resources depends on a combination of resource management strategies and climatic conditions. Different livestock groups in this regard have varying degrees of susceptibility to stress conditions such as more frequent and longer periods of drought under a changing climate. For instance, cattle known for slower biological turnover are considered more vulnerable to feed shortages during drought than small ruminants and camels (Lesnoff et al. 2012).

2.7 Assessing perceptions towards climate variability: an overview

Most research on perceptions of climate dealt with temperature and rainfall (that is amount, annual distribution, start and end dates). Meteorological data is often used to confirm villagers' assessments or refute them for long-term perceptions (Boissière et al., 2013). The most common way to evaluate climate variability is by using meteorological observations. For example, in rain fed semiarid agriculture the onset of the rainy season often determines the length of the growing period and thereby suitable combination of crops (Mugalavai et al., 2008). However, rainfall changes rarely produce the type of significant trends that temperature does. For climatic exposure and impact studies the main discourse is defined by quantitative modellers. Outputs, such as the IPCC reports, show that for many parts of Africa the exposure to new climatic conditions is projected to reach beyond previously experienced extreme events (Boko et al., 2007). Other previous studies have dealt with perceptions of seasonality (Bryan et al. 2009, Bandyopadhyay et al. 2011), perceptions of risks and threats related to climate variability (Grothmann and Patt 2005, Adger et al. 2009) and local knowledge in forecasting weather and adapting to climate variability.

2.7.1 Indigenous knowledge and climate variability

Beliefs and attitudes towards climate change depend on contextual factors including access to climate information and experiential learning. For instance, most scientists working in disciplines contributing to studies of our climate accept that climate change is almost certainly being caused by human activities (Hansen et al. 2012). Indigenous people with limited access to climate information are more likely to attribute changing climatic conditions, particularly extreme weather events, to a change in their rituals and cultural practices. According to Gyamphoh (2008), indigenous knowledge or traditional knowledge, has over the time played significant role in solving problems that are related to climate change and variability in developing countries. Some authors encourage collaboration between scientists and indigenous people, but highlight the uncertainties and methodological challenges of eliciting local knowledge (Sheil and Lawrence 2004; Couzin, 2007). Variations between local perceptions and biophysical data have generally raised concerns about the validity of local knowledge (Hansen et al. 2004; Sànchez-Cortés and Chavero, 2011).

Srinivasan (2005) observed that the importance of indigenous knowledge is to enhance coping and adaptations to climate change. Despite the significant role played by indigenous knowledge in different areas of climate change, it is neglected in academic, policy and public dialogues (Gyampoh et al., 2008; Srinivasan, 2005). Incorporating indigenous knowledge into climate change policies can lead to development of effective coping strategies that are cost effective, participatory and sustainable (Nyong et al., 2007). Some prior studies suggest that to improve estimates of climate impacts on agricultural systems and contribute efficiently to adaptation research, there is a need to know more about how farmers perceive climate and how they respond, in both the short- and long-term, to variable climate conditions, including the magnitude and frequency of extreme conditions (Smit et al., 1996).

2.8 Coping and adaptive strategies

Most studies on climate impacts have used the top-down approach (Deressa 2003; Gbetibouo and Hassan, 2005; Gbetibouo, 2009). According to Gbetibouo (2009), in the top-down scenario-based approach, adaptations are assumed and are invariably treated as primarily technical adjustments (for example, changing to different crops, adopting efficient irrigation systems, or altering production systems) to the impacts identified. Most of these adaptations represent possible or potential adaptation measures, rather than measures that have actually been adopted. This type of approach can be found in spatial analysis, climate impact modelling, and Ricardian studies. In their research on local perceptions of climate variability and change in tropical forests of Papua in Indonesia, Boissiere et al. (2013) considered two different categories of local responses to climatic variations: coping and adaptive responses.

The difference between them has been widely discussed in the literature on development, food security, and climate change (Davies 1993, Berkes and Jolly 2002, Smit and Wandel 2006). Coping responses are unplanned, reactive, and short-term responses to immediate threats, whereas adaptive responses or strategies refer to proactive and anticipatory changes over long periods to reduce the impacts of recurrent threats or gradual changes (Davies 1993, Berkes and Jolly 2002).

Davies (1993) differentiates coping strategies, which do not modify prevailing systems (e.g., production systems, social or economic structures), and adaptation, which implies changes in law systems or the moral economy. Coping strategies can also be preventive. For example, Cooper et al. (2008) consider diversified cropping in which failure of any one is tolerable and failure of all is unlikely. Coping mechanisms are developed by individuals or households and adaptive strategies occur at the community level or above (Berkes and Jolly 2002, Osbahr et al. 2008). In their study, Boissiere et al. (2013), their results showed that local perceptions of seasonality and climate variability differ mainly according to village locations and the surrounding ecosystems, which determine local livelihoods. Furthermore, some differences in perceptions were observed between gender and age groups, in relation to their different activities and experience about how their activities are affected by climate variations. For example, men understand better how events influence the availability of the wildlife they hunt in the forest, and women how cultivated areas are affected.

A recent study conducted by Salick and Byg (2009) indicated that local knowledge and experience have helped to advance understanding of climate change and its impacts on agriculture. Another study on coffee producers in Central America and Mexico (Tucker et al., 2010) supports the importance of local knowledge and perception of climate as a critical ingredient in guiding policy responses on adaptation. In South Africa and Ethiopia, research highlighted the role of perception in understanding the importance of education and awareness building and in identifying available options to enable farmers to adapt to climate variability (Bryan et al., 2009).

Legesse et al. (2012) contended that understanding perception and adaptation strategies of individual households helps to generate additional information relevant to policy and interventions to address the challenges of sustainable development in the light of variable and uncertain environments. Mahmood et al. (2010) reiterated the importance of measuring perception level about climate variability and formulation of coping strategies.

Thus, a better understanding of farmers' perception of climate variability and ongoing adaptation measures as well as their decision-making process is important in formulating policies aimed at promoting successful adaptation of the agricultural land-use system.

Literature indicated that some farmers in Limpopo province have been experimenting with climate adaptation measures such as modifying their planting dates, increasing their irrigation potential, and changing the amount of land used for cultivation (UNICEF, 2011). A study in Limpopo Province done in the Vhembe district, found that some farmers in the area do already use adaptive strategies to make agriculture more resilient to climate variability. For instance, they have already turned to drought-resistant varieties, crop diversification, planting more water-efficient crops or crops that require less water overall, adjusting fertilizer input, using rainwater harvesting techniques, and even monitoring local weather indicators (Mpandeli, 2014).In another study by Phokela and Mpandeli (2012), it was discovered that by simply just providing farmers' information about drought does not strengthen their resilience to it, and has no positive correlation to the farmers experiencing food scarcity. This implies that along with improving access to credible climate change and variability information, there is a need for more rigorous and involved training for farmers on how to use the available information optimally.

2.8.1 The relationship between farmers' perceptions, coping and adaptation strategies

According to Smit and Wandel (2006), the concept of adaptation is relatively new for the research community and has its origins in natural science. Adaptation has been used for a longer history in ecology, natural hazards and risk management fields (Smit et al., 1996). According to Phuong (2011), adaptation refers to the process of adapting and the condition of being adapted. Smit et al. (1996) also defined adaptation as to any adjustment, whether passive, reactive or anticipatory, that can respond to anticipated or actual consequence associated with climate change. Smit et al. (1996) stated that adaptation involved adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events, together with longer-term climate change.

Adaptation is the ability of the system to adjust to climatic change and variability; to moderate potential changes; to take advantage of opportunities; or to cope with the consequences (Parry et al., 2007). According to Bradshaw et al. (2004), major adaptation options in the agriculture sector include crop diversification, mixed crop, livestock farming systems, using different crop varieties, change in planting and harvesting dates, and mixing less productive, drought-tolerant varieties and high yield water-sensitive crops. Other strategies include planting trees, improving weather forecasts, reducing number of livestock, setting aside grazing areas, and introducing zero grazing reversed by afforestation on the damaged watershed (Adosi, 2007).

According to Low (2005), a lot of the coping mechanisms to climate change and variability contain activities that do not have formal systems recognition by government agencies. Orindi and Murray (2005) suggest that coping strategies for seasonal food shortages include petty business, changes in diet, fewer meals, and loans from traders. An important issue related to adaptation in agriculture as indicated by Bryant et al. (2000) is how perceptions of climate change are translated into agricultural decisions. If farmers learn gradually about the change in climate, Maddison (2006) argues that they will also learn gradually about the best techniques and adaptation options available. According to him (Bryant et al. 2000) farmers learn about the best adaptation options through three ways: (1) learning by doing, (2) learning by copying, and (3) learning from instruction. There is recognition that farmers' responses vary when faced with the same stimuli. Such varied responses, even within the same geographic area, are partly related to the variety of agricultural systems involved and the different market systems in which farmers operate (Bryant et al. 2000).

2.9 Conceptual framework

This study adopted a conceptual framework (Figure 2.7) that integrates the components of the socio-cultural context of the study area, the local climate and climatological evidence in order to assess farmers' perceptions of climate variability. A similar approach was employed by Amadou et al. (2015) in the Upper East Region of Ghana. The framework comprises three levels:(1) the first level describes key variables of the above-mentioned components (socio-cultural context, local climate and climatological evidence), (2) the second level shows a link between the two sources of data on climate change and variability, and (3) the last level of the framework highlights the influence of the awareness and interpretation of climate phenomena on farmers' decision and choice of responses.

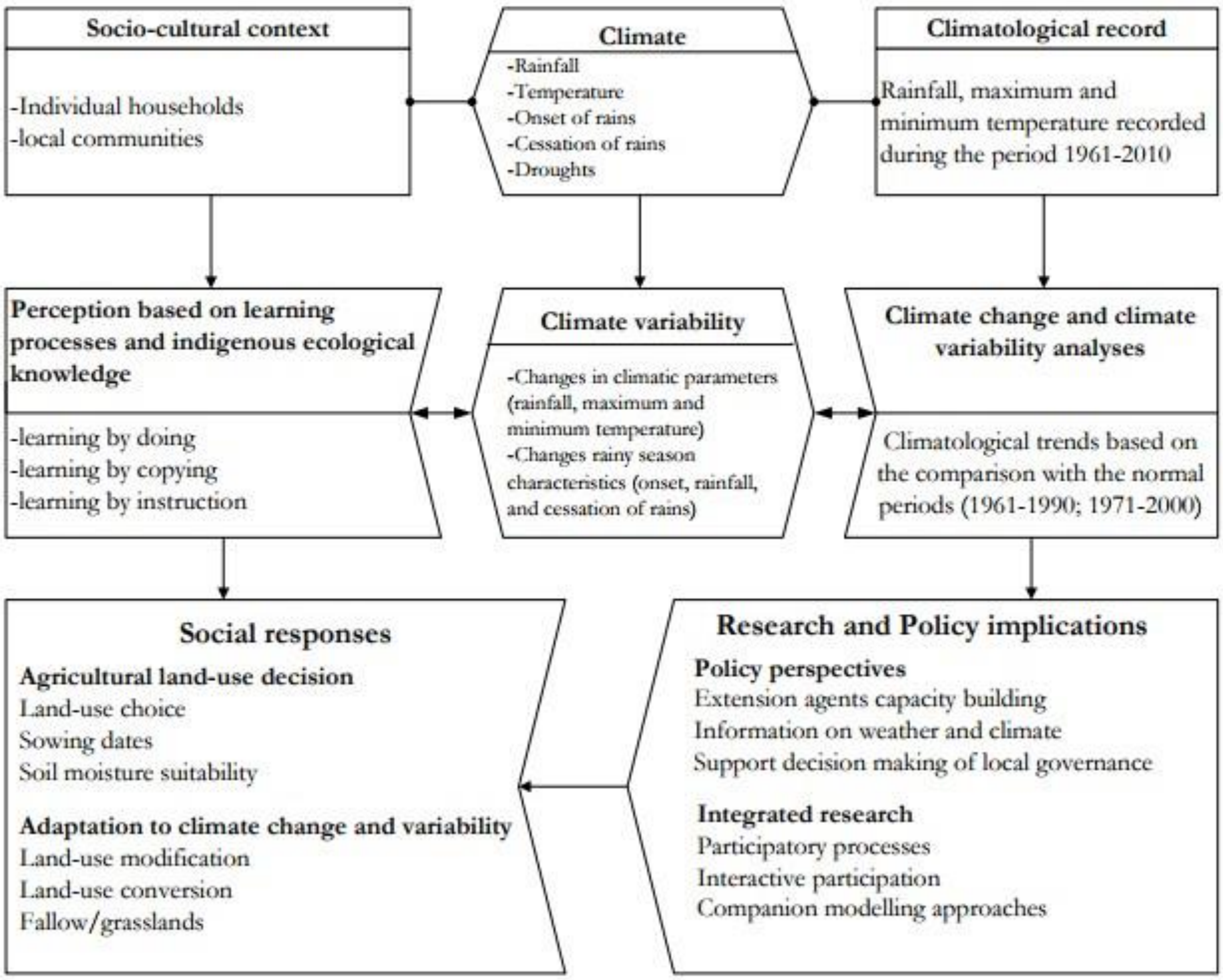


Figure 2.6. Schematic representation of conceptual framework integrating the socio-cultural context, climate and the climatological record (Amadou et al., 2015)

Villamor et al. (2014) and Salick and Byg (2009) concur that perception is determined by indicators such as age, experience, environment and information on weather and climate. The way farmers perceive climate change and variability is reflected in the choice of land-use and adopted cropping systems (Maddison, 2006; Simelton et al., 2013; Roncoli et al., 2002). Komba and Muchapondwa (2012) equally acknowledge that in order to undertake appropriate strategies towards adaptation, farmers' ability to perceive climate variability is a key pre-requisite. The coping and adaptation strategies of the smallholder farmers depend, to a very large extent on their perception knowledge level and sources of information about climate change and variability (Maddison, 2007; Gbetibouo, 2009; Acquah and Onumah, 2011; Moyo et al., 2012). Weber (2010) identified media reporting as one of the main sources of such information. However, literature contends that the interplay between the socio-cultural context, the availability of, and access to climatological data will ultimately drive any coping and adaptation strategy (Deressa, et al., 2008 and Maddison, 2007).

2.10 Protection Motivation Theory (PMT)

Adaptive capability is the ability of a farmer to influence his vulnerability through adaptation. Adaptation is the action taken by a farmer to moderate the impacts of future droughts or to better cope with the consequences (Adger, 2006). A farmer's adaptive capability depends on the available resources and the ability to use the resources effectively in the pursuit of adaptation. Besides socioe-conomic and institutional factors, adaptive capacity also depends on psychological processes such as risk perception and efficacy beliefs (Kuruppu and Liverman, 2011).

This current study uses the Protection Motivation Theory (PMT), to relate socio-cultural, economic and psychological factors (behaviour) to adaptation. The PMT explains the effects of fear threats on attitudes, behaviour and responses in order to understand an individuals' intention (motivation) to adopt recommended preventive behaviour (Figure 2.8). Since the development of PMT theory, it has been applied to a wide range of topics beyond health-related issues, for example to injury prevention, political issues and environmental studies, (Floyd, Prentice-Dunn et al., 2000).

Psychological factors have a considerable influence on adaptation behaviour. Focussing on the role of perception for adaptation purposes, Grothmann and Patt (2005) employed the PMT to explain the socio-cognitive processes of risk perception and coping perception that farmers show when faced with climate variability and extreme events. In the past few decades, a few studies have applied the PMT to analyse farmers' behavioural intention to adopt adaptation measures to climate change (Grothman and Patt, 2005; Milne et al., 2000; van Duinen, 2011). These researchers explained the PMT based on three major variables comprising, *threat appraisal*, *coping appraisal*, and *behaviour* (adaptive or maladaptive).

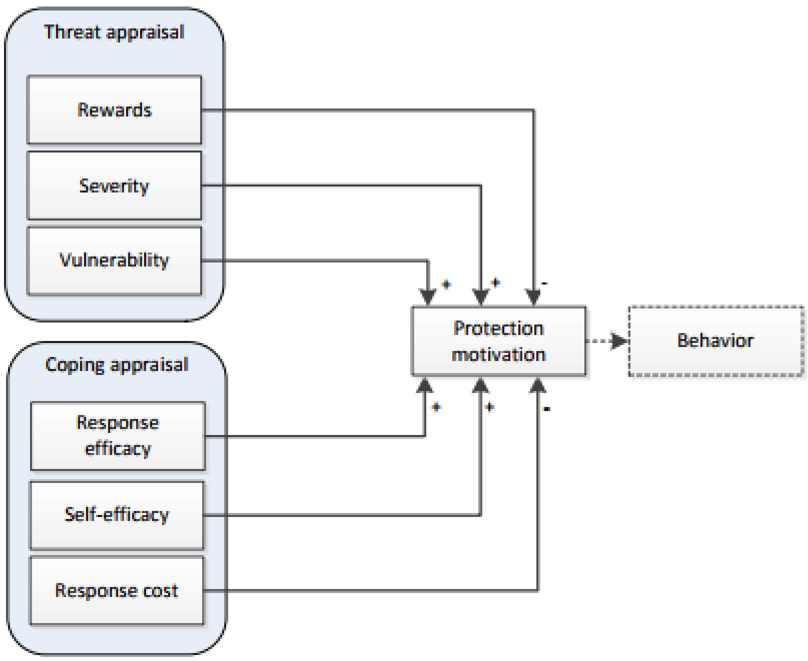


Figure 2.7. Protection Motivation Theory Model

- *Threat appraisal* will result in higher protection motivation if the individual perceives it is more vulnerable to the threat and/or the severity of consequence is high. PMT also states that high rewards will result in lower protection motivation. If the threat of climate change is deemed to be high risk, people protect themselves from the threat.

- In the *coping appraisal* process, the farmer calculates the ability to cope with and avert the threat. The coping appraisal will result in higher protection motivation if the individual perceives that the suggested coping method is meaningful and simple to employ. More concretely, positive evaluations of response efficacy and self-efficacy will lead to higher protection motivation, whereas higher response costs will lead to lower protection motivation.

- *Behaviour.* A farmer's threat and coping appraisal positively influence a farmer's' protection motivation; the intention to (not) initiate, continue or inhibit adaptive responses that prevent damage.

The protection motivation might result in adaptive coping or maladaptive coping. Adaptive coping modes are responses that prevent damage. Maladaptive coping modes includes avoidant reactions due to denial of the threat or wishful thinking. It also includes adaptive coping responses that are not effective. A farmer would show adaptive coping behaviour when the risk perception resulting from the threat appraisal process and perceived adaptive capacity resulting from the coping appraisal process are both high. Low risk perception and/or low perceived adaptive capacity would both result in maladaptive behaviour.

2.11 Conclusion

As evidenced by literature, several factors affect perceptions and responsiveness of smallholder farmers to climate variability. Some of the factors are within the farmer's control while others are beyond the farmer's control. The PMT has also explained that psychological factors have a considerable influence on adaptation behaviour. Therefore, this study aimed at covering the knowledge gaps regarding the impacts of climate variability, perceptions on climate variability and adaptation in rain-fed smallholder farmers.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Introduction

This chapter outlines the methods used to collect data and to analyse the data. It outlines the background of the study area, data requirements and data collection procedures. In order to achieve the research objectives a number of methods and data sources were used. Data was collected through questionnaires interviews, focus group discussions and from archived climatological data.

3.2 Overview of the study area

The study was carried out it Botlokwa Village in the Molemole Local Municipality which is in the Capricorn District Municipality, of Limpopo province, South Africa (Figure 2.9). Limpopo Province is situated in the northern tip of South Africa. Botlokwa is the smallest municipality in the Capricorn District with 14 wards. According to StatsSA (2011), Molemole Municipality has a total population of 108,321 people and 30 043 households and unfortunately, 43% of the population are not economically active. Molemole has significant potential in terms of tourism, due to its rich heritage and cultural resources and its location advantage (the N1 links Molemole to Zimbabwe). The municipality has five tribal/traditional Authorities which are Machaka, Ramokgopa, Manthata, Makgato and Moloto/Moletsi and are responsible for R188 settlements of the Municipality (Molemole IDP, 2015/16). The study area has a widely dispersed settlement structure that is characterised by poor accessibility, low density, and large distances between settlements. The settlement types in Molemole Local Municipality vary from urban settlements to rural villages and farm homesteads, and from densely populated areas to sparsely populated areas (Molemole IDP, 2015/16). This spatial structure is the result of a variety of factors which impacted on the area over many years. The major influence on the spatial structure is the spatial policies of the apartheid era (Molemole IDP, 2015/16). The basic languages in Molemole are Sepedi and Setlokwa (dialect of Sepedi).

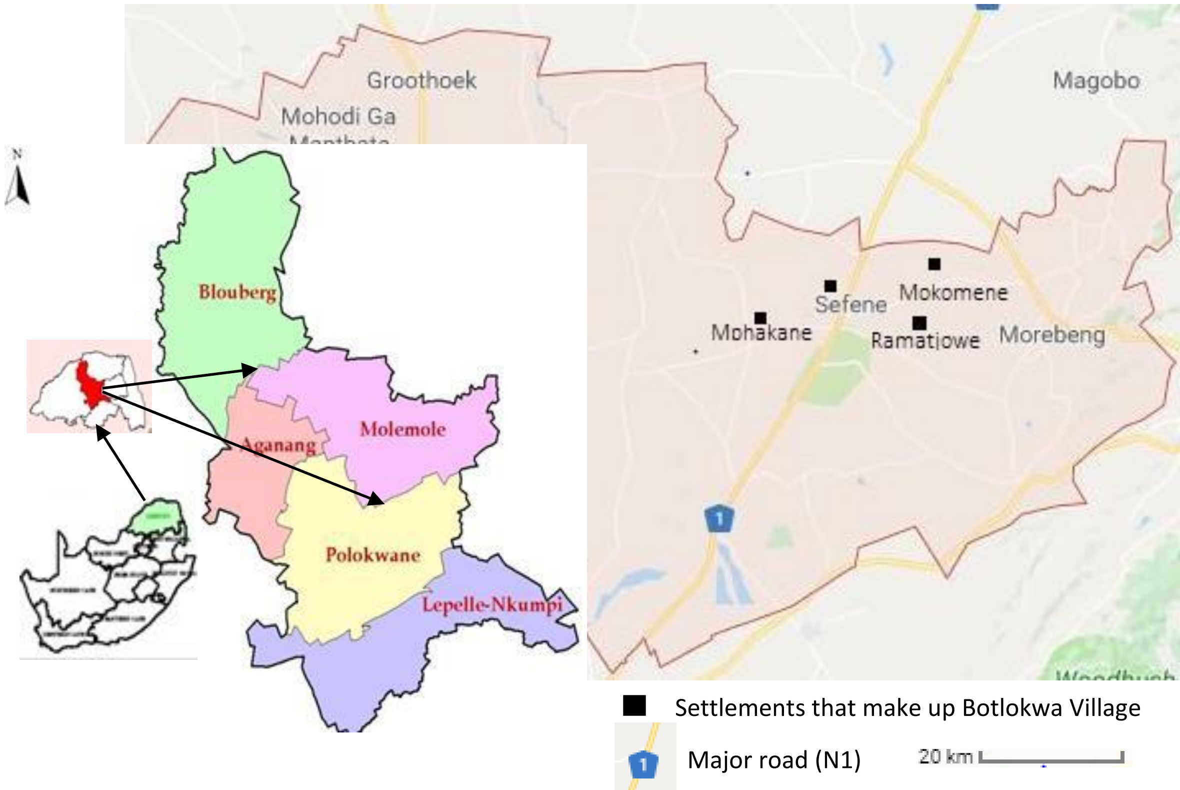


Figure 2.8. Location of study area. Inset: situation of Molemole Municipality in Capricorn District, Limpopo Province, South Africa.

Molemole Local Municipality is clustered into two groups, the Western and Eastern parts of the municipality. The first cluster of settlement which is the largest concentration of settlements occurs along the N1 road from Polokwane to Makhado covering Mphakane, Ramatjowe, Mokomene and Sefene. Interestingly, these settlements have primarily developed along the major road (N1) serving the Local Municipality and collectively known as Botlokwa Village. The second cluster of settlements include Mogwadi and rural villages around Mohodi and Maponto to the western section of the Municipality (Molemole IDP, 2015/16). Of the total agricultural land, 40% is utilised for commercial farming and 60% for subsistence farming.

Botlokwa is located along the N1 between the city of Polokwane and town of Makhado and is the largest settlement in the Molemole Local Municipality with an estimated 48 909 population and 12 893 households (StatsSA, 2011). The area is predominantly rural in nature under tribal authority (Machaka-Ramokgopa-Makgatho Tribal Authority). Botlokwa Village is predominantly rural and characterised by high levels of poverty and inequalities and a large part of its economy depends on agricultural development. The area is water scarce and relies mainly on ground water for sustainability. The municipality falls within the summer rainfall region and the western part of the municipal area is prone to drought. Winter seasons are usually mild and mostly frost-free and temperatures rarely fall below 0ºC while summer maximum temperatures often exceed 35ºC in certain parts. The municipality experiences low annual rainfall which is strongly seasonal with easily identifiable wet and dry seasons. Wet seasons start from October to March and contributes 85% of the annual rainfall. The largest portion of the municipality experiences a mean annual rainfall of between 300mm and 500mm (Molemole Integrated Environmental Management Plan and Framework Report, 2008). Botlokwa Village is dominated by the mixed Bushveld vegetation type forming part of the Savanna Biome and the vegetation found here varies from dense short bushveld to a more open tree Savanna (Molemole Local Municipality 2017-18 IDP report, 2017). This vegetation type is found in areas where the rainfall varies between 350mm and 650 mm per annum and the altitude comprises low relief plans at an altitude range of 700m to 1000 m (Molemole Local Municipality 2017-18 IDP report, 2017). The study area is semi-arid and is frequently affected by dry spells, often growing into severe drought.

3.3 Research design

The research adopted a mixed-method design. RDSU (2003), argues that using both qualitative and quantitative methods help to triangulate and validate research findings. The advantage of using qualitative methods is that they are effective in identifying intangible factors, such as social norms, socioeconomic status and gender roles. When used along with quantitative methods, qualitative methods help to interpret and better understand the complex responses and the implications of quantitative data (Liwenga, 2003). The advantage of using quantitative methods is that it achieves high levels of reliability of gathered data due to controlled observations or mass surveys and it eliminates or minimises subjectivity of judgement (Matveev, 2002). Other studies from different regions across the world used similar approaches and methods. For example, studies in Africa, Latin America and Asia used methods such as researcher's observation, a questionnaire survey, focus group discussions, and historical timelines (Paavola, 2008; Eriksen & Silva, 2009, Mertz et al., 2009; Nielsen & Reenberg, 2010).

3.4 Sampling

3.4.1 Sampling frame

Botlokwa was purposively selected for the research because it is the largest village in the municipality. In addition, information on the village was readily available from the municipal offices. Subsistence farming dominates in the village, making it a suitable choice for a study on the perceptions of smallholder farmers on climate change and variability. Small-scale farmers were basically targeted for this study and regarded as farmers operating on a farm land of less than 10 hectares irrespective of their gender.

3.4.2 Sample size

There are different opinions on the ideal sample size to be selected for study. Alreck and Settle (1995) have suggested that under certain conditions, such as time and resource limitations, a sample size of 5-10 % is satisfactory and therefore recommended. According to records from the Botlokwa Community Liaison Officer, there were 182 officially registered subsistence crop farmers in the village. The sample population was drawn from the 182 farmers.

3.4.3 Sampling method

The study used purposive sampling. According to Teddlie and Yu (2007), purposive sampling techniques are used to select units (e.g., individuals, groups of individuals, institutions) based on specific purposes associated with answering a research study's questions. Thus, study units are purposively or intentionally selected because they are in a position to supply the information that is sought in the study. In this study, farmers were selected and interviewed based on the following criteria; (1) practiced subsistence agriculture (crop farming) for at least 5 years, (2) registered as a subsistence farmer in the community data base, (3) lived in the village for over 20 years, and (4) availability and willingness to participate in the study. Based on the aforementioned criteria, 125 participants were recruited from the total population of 182.

3.5 Data collection

Two types of data were sourced in this study; primary data (through interviews and focus group discussions) and secondary data (climatological data, precisely temperature and rainfall).

3.5.1 Primary data

Collection of data was undertaken in two phases; firstly, through focus group discussions (FGD), and secondly through administration of semi-structured questionnaires. In order to eliminate any undue influence due to prior exposure to and interaction on issues pertaining to the study, participants in the FGD were excluded from the second phase of the data collection process.

3.5.1.1 Focus group discussion

Focus group discussions were undertaken with a group of farmers comprising local elders, heads of households, representatives of women and youth groups. A total of 10 participants were identified through the assistance of community leaders (also referred to as area Chiefs). The discussions were held with two groups of 5 participants each (Figure 10. The FGDs were used to assess the community's perceptions of climate variability; trends in weather patterns; impacts of climate change on their livelihoods and how they are coping and adapting to the impacts (Appendices 1-2). The FGDs had the advantage that they solicited more information from local people, since they encouraged participation and dialogue between local people and researchers, as well as among local people themselves. The emphasis to local peoples' participation in research is the argument that local people have experience, knowledge and the ability to conduct their own analysis.

At the end of the FGDs, field visits to selected farms were undertaken with participants of the FGD in order to substantiate some of the issues raised during discussions but also have a first-hand experience of the implementation of current copping and adaptive strategies (Figure 3.1)

Figure 3.1. Focus group discussions with smallholder farmers

Figure 3.2. Field observations of subsistence farming practice in Botlokwa Village.

3.5.1.2 Administration of semi-structured questionnaires

A total of 125 semi-structured closed ended questionnaires were administered to smallholder farmers. The formulation of interview questions were guided by the objectives of the study (Newing, 2011). Information sourced was characterised into three categories namely; (a) famers' demographic information (comprising gender, age, level of education, years in farming and farming systems), (b) information on knowledge and perceptions (memories and experiences regarding climate variability including temperature and rainfall variability, onset, cessation, duration, amount, frequency and intensity), and (c) and information on behaviour (adaptation strategies, including use of indigenous knowledge systems). The questionnaire was therefore divided into three sections that is, part 1, 2 and 3 (Appendices 1-4).

3.5.1.3 Pilot study

The questionnaire was first developed and tested with a small group (10 farmers) before it was used on a larger scale. During the pilot study, it was discovered that some farmers were not comfortable answering certain questions (e.g. income and marital status) which were regarded as very personal, such questions were either reframed or totally removed from the list. There were also some open-ended questions which were later converted to close ended ones because farmers' opinions about such questions were not easily obtainable and as such made the completion of the questionnaire lengthier and time consuming.

3.5.2 Secondary data

Climatological data used in the study were sourced from the Polokwane International Airport Weather Station courtesy of the South African Weather Service. The weather station is the closest to the selected study area.

3.5.2.1 Temperature and rainfall data

Climatological evidence involved temperature and rainfall data over the past 30 years (1986 – 2015). The 30-year average is considered a climatological normal and is useful for predicting climate change/variability (Kihupi et al., 2015). Trends in temperature and rainfall were determined from annual averages (coefficient of variation, maximum, minimum, mean and standard deviation) over the 30 year time frame. Time series analysis were equally performed in order to investigate correlations in mean annual data sets (Gwimbi, 2009). Other rainfall parameters such as onset, cessation, duration and number of days without rain (dry spells) were also determined from the time series data.

Evaluation of farmers' perception of climate variability was based on a comparison of their responses from both interview sessions and FGD with climatological evidence. In order to accommodate farmer's memories without necessarily compromising validity of their perceptions, climate variability was assessed on a year-to-year basis over the past 5 to 10 years (Kihupi et al., 2015).

3.6 Data Analysis

3.6.1 Interview and focus group discussion

Quantitative data (from semi-structured interviews) were analysed using Statistical Package for Social Science (SPSS 23) and Microsoft Excel (for drawing graphs and charts). A SPSS data base capturing all elements of the questionnaire was created. Prior to populating the data, they were cleaned and screened to eliminate errors (Moyo et al., 2012; Maponya and Mpandeli, 2012). Responses were coded and arranged thematically using SPSS. Descriptive statistics were used to characterise the demographic data, farmer perceptions and adaptation strategies. Descriptive statistics were complemented with tables and figures for graphical representation and visual comparison (Debela et al., 2015).

Qualitative data from the FGD were analysed using Thematic Content Analysis (TCA). The most recurrent themes emerging from the TCA were used to express farmer's perceptions on climate variability and adaptation strategies.

3.6.2 Logistic Regression Analysis

A logistic regression analysis was used to determine factors that influence smallholder farmers' perceptions and choice of response measures. Three groups of factors were tested: (i) demographic characteristics (ii) access to information and (iii) educational level. Using a dependent variable Y, (in the context of the current study was adaptation or a coping strategy) a relation can be established based on the expression:

$$Y=b0 + bX1 + bX2+\dots\dots\dots. +bXn \qquad (1)$$

Whereby, Y= either 0 or 1 with 0 implying no use of a strategy and 1 represents use of a strategy.

3.6.3 Likert Scale

Likert (1932) developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them, and so tapping into the cognitive and affective components of attitudes. A Likert Scale was used to assess farmers' perceptions on climate variability and adaptive strategies. A Likert scale assumes that the strength/intensity of experience is linear, i.e. on a scale from strongly agree to strongly disagree, and assumes that attitudes can be measured. In its final form, the Likert Scale is a five (or seven) point scale which is used to allow the individual to express how much they agree or disagree with a statement. In the context of this research, for each perception measuring statement respondents were asked to state whether they agree, disagree, observed no change or were not sure (undecided).

3.6.4 Weighted Average Index

In determining farmers' perceived importance of adaptation practices, respondents were requested to score selected practices based on a 0–3 scale, where 3 is the most important practice and 0 is the least important practice. The adaptation practices were then ranked using the weighted average index (WAI):

$$\text{WAI} = \sum FiWi / \sum Fi \quad (2)$$

Where, F = frequency of response; W = weight of each score; and i = score

3.6.5 Adaptation Strategy Index

To identify those adaptive strategies which held relative importance over others an adaptation index procedure was implemented, as measured by the expression below (equation 2). Farmers' response options for components were placed on a continuum (Likert scale) as high, medium, low and not at all. Scores assigned to responses were 3, 2, 1, and 0, respectively. The relative importance of adaptation strategies to climate change was calculated based on the following index formula proposed by Uddin (2012):

$$ASI = AS_n \times 0 + AS_l \times 1 + AS_m \times 2 + AS_h \times 3 \qquad (3)$$

Where,

AS_n= Frequency of farmers rating adaptation strategy as having no importance.

AS_l= Frequency of farmers rating adaptation strategy as having low importance.

AS_m= Frequency of farmers rating adaptation strategy as having moderate importance.

AS_h= Frequency of farmers rating adaptation strategy as having high importance.

3.7 Ethical considerations

Permission to conduct the study was obtained from UL Turfloop Research and Ethics Committee (TREC) and relevant authorities (Molemole Local Municipality). The rule of confidentiality was upheld. Besides, the participants were informed beforehand that should parts of their interview be used in a publication, their names would not be recorded and any details related to their privacy will be kept confidential. No harm was posed to the respondents and they participated in the research voluntarily. A consent form was used to affect the ethical consideration.

3.8 Conclusion

This chapter detailed the methodology employed to assess smallholder farmers' perceptions on climate variability in relation to climatological evidence in the Molemole Municipality. It elaborated on the study area, research design, population and sampling procedure. Comprehensive descriptions have been provided on the development and administration of questionnaires, pilot studies, validity and reliability of the questionnaire as well as the statistical parameters that were used for data analysis.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results of the study. Data was collected through procedures elaborated in the previous chapter. In addition to data presentation, a discussion of the results is also carried out in line with set themes that speak directly to the objective of the study.

4.2 Demographic Characteristics

Demographic characteristics of smallholder farmers analysed for this study were age, gender, level of education, farm experience, farm size and accessibility to climatic information. These variables have implications on smallholder farmers' perception of climate variability and adaptation to climate variability.

4.2.1 Age

The distribution of the respondents according to age was as presented in Table 4.1. Thirty seven percent of the respondents were aged between 41-50 years old, 26% between 51 and 60 years old and 24% above 60 years old. Farmers less than 30 years made up the lowest percentage of the farming communities (2 %), followed by the 30 to 40 age bracket (11%). The distribution of the latter age groupings suggest subsistence agriculture is not perceived as a viable source of livelihood by the active youth population in Botlokwa Village. The reliance of the sector on the more elderly, has a direct bearing on use of adaptation strategies such as technology and accessibility to information. Conversely the age distribution also suggests a bias towards use of traditional methods (IKS).

This is however consistent with literature which indicates the predominance of the elderly in subsistence agriculture (Imai, 2003; Gbetibouo and Hassan, 2005; Seo et al., 2005; Sherlund et. al., 2002). Galvin et al. (2001) however underscored the influence of age on farmers' decision. For example, Seo et al. (2005) and Sherlund et al. (2002) found negative relationship between age and farmers' decision to adapt to climate variability, while Imai (2003) and Gbetibouo and Hassan (2005) reported positive relationship.

Table 4.1. Age of respondents

Age (years)	Frequency	Percentage (%)
<30	2	2%
30-40	14	11%
41-50	46	37%
51-60	33	26%
>60	30	24%

4.2.2 Gender

The total number of male respondents in the study area was 88 (70.4%) and females were 37 (29.6%). The results indicate a significant disparity in the number of male and female smallholder farmers in the study area. The percentage of female respondents was mostly dominated by widows who had to fend for themselves and their children. Most of the women in the study area were focused on other businesses (such as retailing of farm produce) besides farming to sustain their families.

4.2.3 Education level

In South Africa, research emphasized the role of perception in understanding the importance of education and awareness building and in identifying available options to enable farmers adapt to changing climate (Bryan et al., 2009). Results show that most farmers in all the study area attained secondary education (46%), followed by 26% with primary education, with 17% haven attained the highest level of education (college and/or university education). Only 11% of farmers had no education background (Figure 4.1). Therefore, the average literacy level of farmers was moderate. The level of education is a very important factor since farmers are decision makers particularly when it comes to issues of understanding weather forecasting, and adoption of suitable adaptation strategies.

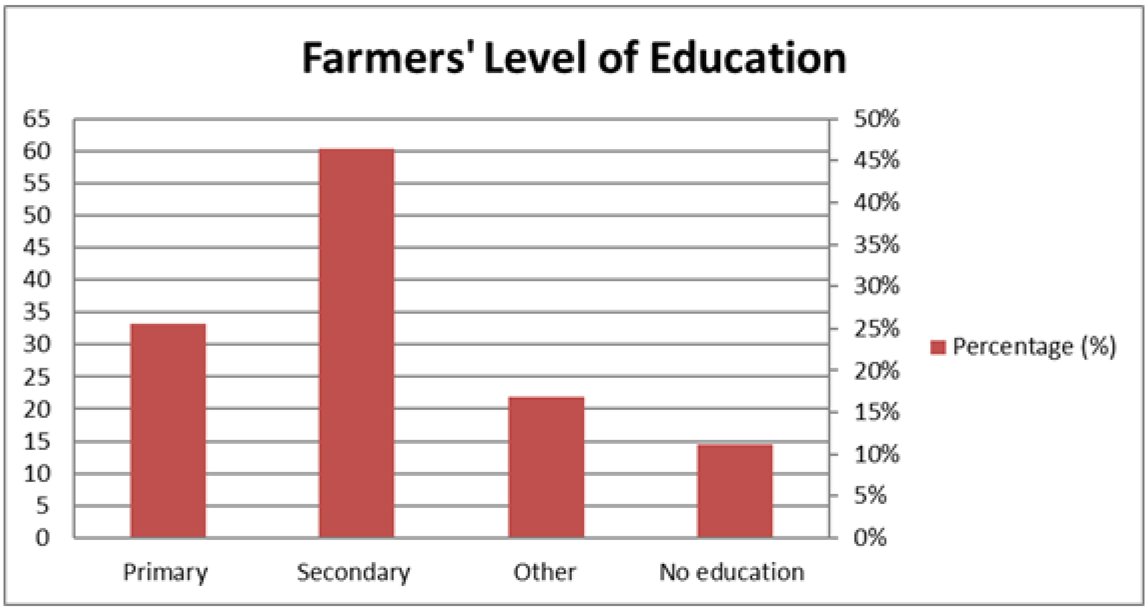


Figure 4.1. Farmers' level of education

4.2.4 Farming Experience

Length of farming experience (Table 4.2) was distributed as follows; 5 – 10 years (7.2%), 11–20 years (4%), 21–30 years (25.6%), and >30 years (63.2%). The number of years of farming experience was analysed to measure its influence on farmers' perceptions to climate variability in the study area. The results showed that most of the respondents had a rich farming experience with over 63% of the smallholder farmers haven invested more than 30 years in the sector. This finding are consistent with the predominant age distribution of the farmers.

Table 4.2. Farming Experience

Farming Experience (years)	**Frequency**	**Percentage (%)**
5-10	9	7.2%
11-20	5	4%
21-30	32	25.6%
>30	79	63.2%

4.2.5 Farm size

In total, 90% of the respondents were farming on their own land, while the remaining 10% (mostly women) were farming on land that belonged to either family or friends. None of the respondents were farming on rented land. The size of the farm holdings varied from farmer to farmer, with 64% owning between 0.5 and 1.2 hectares, 31.5% between 1.6 and 2.8 hectares, and 4.5% between 2.8 and 4 hectares. A comparison between farm size and age revealed that farmers older than 60 had smaller farms compared to those of the other age brackets. This can be attributed to the decreasing level of enthusiasm and energy possessed by this older group of farmers.

4.2.6 Access to information

There is a general consensus that knowledge of climate variability is related to availability of and accessibility to information on the climatic regime. From the questionnaire administered it was found that indigenous knowledge and media form the largest sources of information on climatic conditions in the study area. Figure 4.2 reveals that the farmers received information on climatic conditions (that is, rainfall and temperature) from the following three major sources: Media (30.1%), agricultural extension officers (6.9%) and indigenous knowledge (63%). Only 10 of the 125 respondents in the survey said they had heard of the term "climate variability", but they could not explain what the term meant. They had all heard it mentioned on television. This finding of extremely low awareness rates in parts of the rural population is consistent with other studies in West Africa and sub-Saharan Africa (Bello et al., 2013).

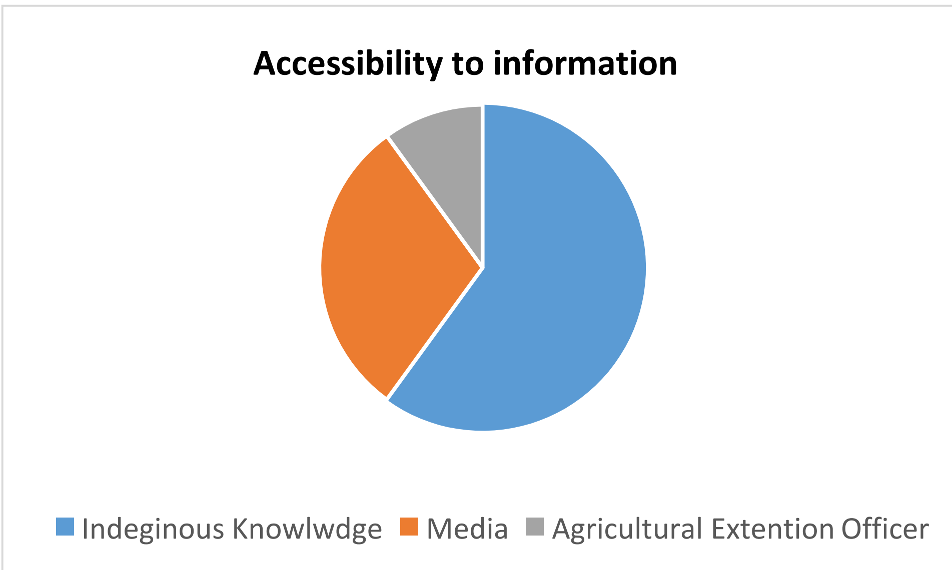


Figure 4.2. Accessibility to Information

4.3 Empirical Evidence of climate variability

Empirical evidence was only based on rainfall and temperature variability records from the selected meteorological station.

4.3.1 Temperature trend

Figure 4.3 shows the mean annual minimum and maximum temperatures between 1985 and 2015 as 11.8ºC and 25.4ºC, respectively with an average of 18.6ºC. It was warmer than normal during the years: 1992, 1998, and 2000, 2002, 2003, 2008, 2012, 2015, and relatively cooler in 2013. The mean annual maximum temperature increased to 26.3ºC and the minimum temperature conversely reduced to 11.5ºC by the year 2015.

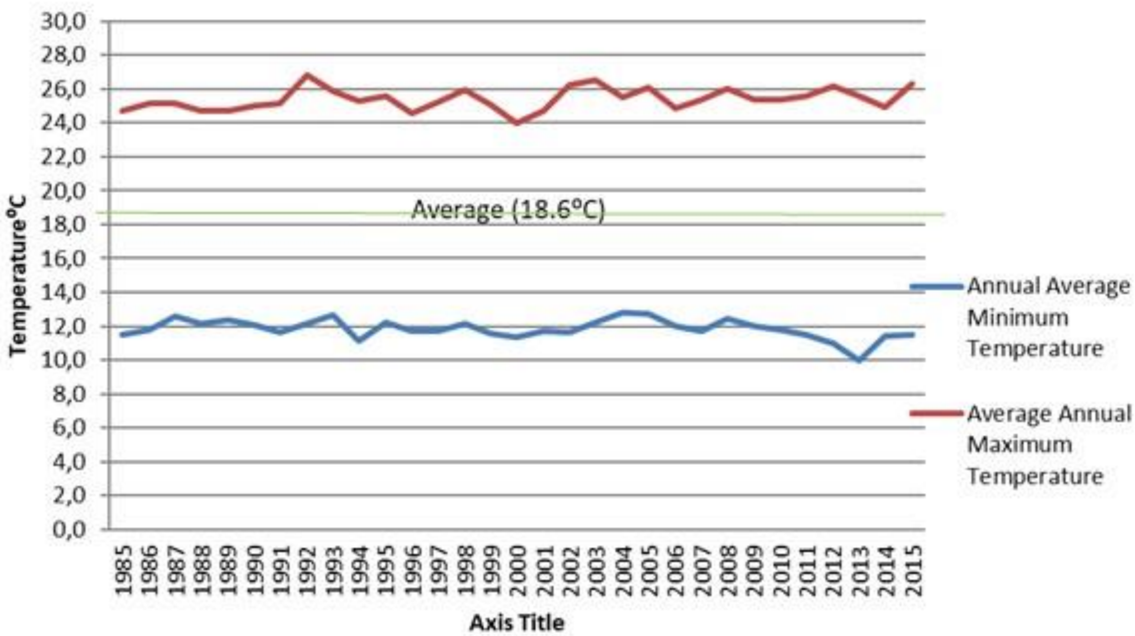


Figure 9.3. Annual temperatures for Botlokwa Village from 1895 – 2015.

4.3.2 Rainfall trend

Annual rainfall trends for Botlokwa Village for 1985-2015 is summarised on Figure 4.4. The average annual rainfall over the study area is 482 mm with a standard deviation of 142.6 mm. Though the rainfall trend of 30 years shows the decrease is not statistically significant at $P<0.05$. The coefficient of variation of annual rainfall is 30 % indicating that it is highly variable from its long-term average. November is the highest (92.3 mm) and contributes 19.16 % of annual rainfall (482 mm), followed by December (18.91 %), January (17.12 %) and February (12.97 %). Least amounts of rainfall were observed during the month of July (2.1 mm) followed by August (3.6 mm), which contribute only 0.44 and 0.75 % to the annual rainfall for the period 1985-2015 respectively. The coefficient of variations of annual rainfalls of October (63%), November (49%), December

(50%) and January (71%) indicated moderate variability and therefore indicated a significant relationship between standard deviation and coefficient variation observed during the months of highest rainfall (Table 4.3).

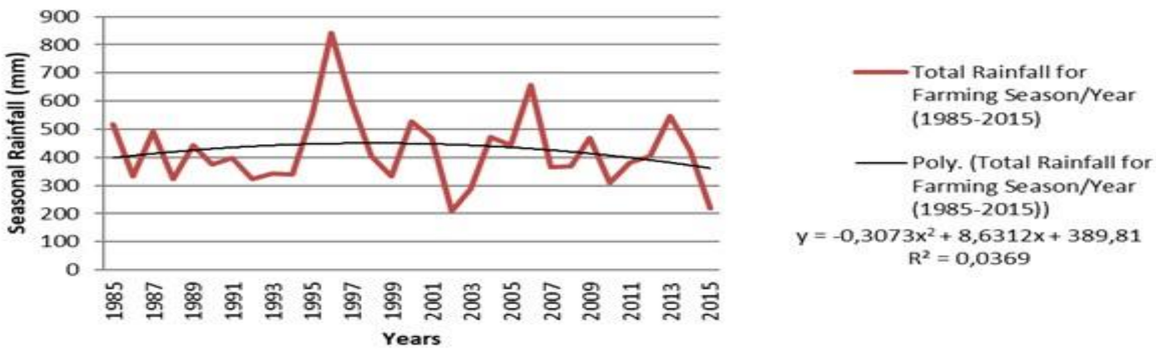


Figure 4.4. Annual rainfall trends for Botlokwa Village from 1985-2015.

4.3.3 Rainfall onset, duration and cessation

Looking at Figure 15, the mean rainfall recorded during the three consecutive months (i.e., JFM= January, February, March, AMJ= April, May, June, JAS= July, August, September, OND = October, November, December), it may be concluded that JFM and OND are the main rainy season in the study area also because over the years maximum rainfall occurred during these months.

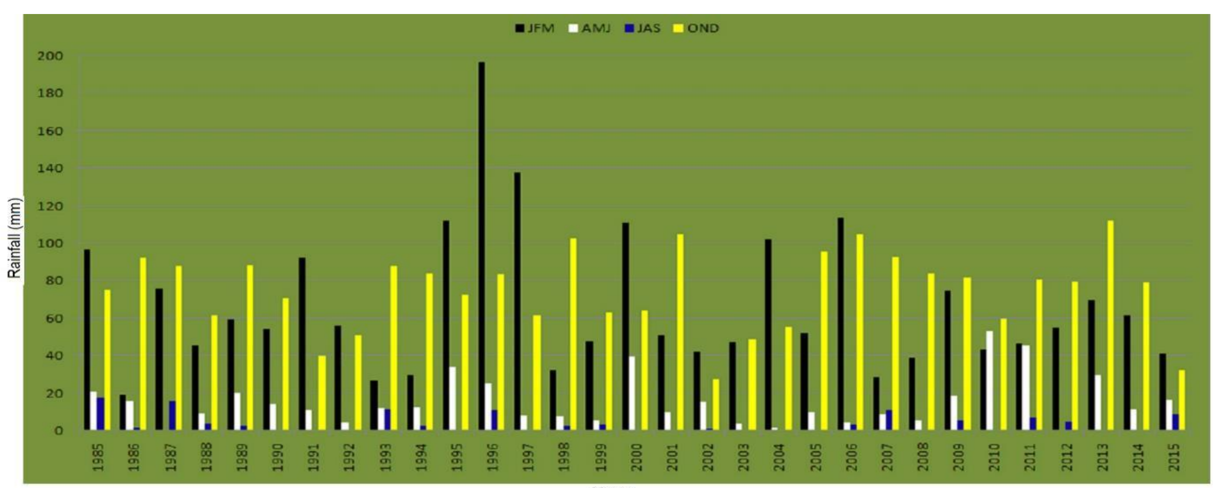


Figure 4.5. Rainfall onset and cessation for Botlokwa Village from 1985-2015.

Table 4.3. Mean monthly and annual rainfall statistics for Botlokwa Village

Monthly Daily Rain (mm) Data for station [0677802 0] - PIETERSBURG - WK Measured at 08:00														
Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total Annual Rainfal l (mm)	
1985	140.1	93.9	56.7	0	61.9	0	1	24.5	27.4	62.2	55.5	108	631.2	
1986	27.2	23.8	7.1	45	2.6	0.9	0	0	4.9	52.6	119.6	103.8	387.5	
1987	98.4	81.1	47.6	1.9	0.1	0	0	32	16.5	34	109.6	120	541.2	
1988	52.8	41.5	42.3	4.3	0	23.7	0	0	11.1	72.4	47.3	65.4	360.8	
1989	24.8	60.4	93	32.7	6.9	21	0	8	0	61.4	107.2	97.4	512.8	
1990	71.1	41.4	50.1	42.2	1.3	0	0	0	1.4	22.2	117.6	73.2	420.5	
1991	150.1	81	46.2	2.2	21.9	8.3	0	0	0	0.6	101.7	18.4	430.4	
1992	104	45.7	19.1	12.3	0	0	0	0	0	24.2	40.2	88.5	334	
1993	18.3	36.1	25.7	36	0	0.2	2	14.9	17.8	18.4	130.7	114.4	414.5	
1994	20.8	25.4	42.1	37.8	0	0	0	7.4	1.3	43.3	75.2	133.1	386.4	
1995	148.2	13.5	174.1	93.9	7.5	0	0	0.3	0.2	28.7	97.8	90.6	654.8	
1996	181.2	331.4	77.2	6.1	65	5.1	28.1	0	5.3	67.1	49.2	134.7	950.4	
1997	267.4	60.3	86	5.6	18.3	0	0	0	1.6	58.5	119.3	6.2	623.2	
1998	19.3	40.5	37.4	23.2	0	0	0	0	7.9	65.5	118.7	124	436.5	
1999	100.3	2.9	40.2	5.2	11.4	0.5	5.4	0	4.4	40.2	73.5	75.3	359.3	
2000	105.4	188.1	40	74.3	20	23.8	0	0	0.6	43.3	67.1	82.2	644.8	
2001	12.1	67.3	73.6	16.7	9.7	3	0	0	0.4	54.5	214.5	45.6	497.4	
2002	102.2	20.8	3.5	22.5	19.5	4.1	0	0.2	2.9	30.2	0	51.4	257.3	
2003	90.6	34.2	16.2	0	0	11.6	0	0	2	6.4	84.3	56.6	301.9	
2004	94.8	109.7	102.2	3.4	0	0.7	2.2	0	0	15.4	32.4	118.1	478.9	
2005	24.5	79.1	53	27.5	0.8	1	0	0	0	0.1	117.3	169.1	472.4	
2006	34.3	173.2	133.1	10.3	2.4	0	0	6.1	2.9	23.1	127.7	164.6	677.7	
2007	25.9	9.2	50.3	25.6	0	0.5	14.2	0	18.7	101.6	133.2	43.7	422.9	
2008	28.3	40.2	48.3	13.6	3	0	0.1	0	0	36.8	146.3	69.4	386	
2009	81.3	114	28.6	0.5	43	12.9	7.5	0	8.3	43	134.6	67.3	541	
2010	91.8	11.7	25.9	144.4	15.3	0.1	0.4	0	0	22.4	85.8	71.4	469.2	
2011	91.8	19.8	28.4	106.6	29	1.5	1.1	19.2	1.3	92.3	51.6	99.1	541.7	
2012	67.6	24.2	72.7	0.2	0	0	0	0	15.2	86.4	72.9	80.2	419.4	
2013	157.8	17.5	33.8	89.6	0	0	0.6	0.1	0.1	48.4	147.5	140.9	636.3	
2014	83.1	6.2	95	33.4	0.8	0	0	0	0	14	24.9	199.1	456.5	
2015	42.7	43.3	37.6	46.7	0.7	1.6	2.4	0	23.3	24.6	59.4	13.4	295.7	
													Mean (mm)	482.0
Total Rainfall per month (mm)	2558.2	1937.4	1687	963.7	341.1	120.5	65	112.7	175.5	1293.8	2862.6	2825.1	Standard deviation (mm)	142.6
Average Rainfall per month (mm)	82.5	62.5	54.4	31.1	11.0	3.9	2.1	3.6	5.7	41.7	92.3	91.1	Coeficient of Variation	0.30
Average % per month	17.12	12.97	11.29	6.45	2.28	0.81	0.44	0.75	1.17	8.66	19.16	18.91		
Monhly standard deviation (mm)	58.3	67.3	36.8	36.0	17.5	7.1	5.7	8.1	7.8	26.1	44.8	45.3		
Coeficient of Vaiation	0.71	1.08	0.68	1.16	1.59	1.84	2.69	2.22	1.38	0.63	0.49	0.50		

Interestingly after 2006, between October and December (OND) always highest rainfall was recorded than the rest of the other seasons. However, before 2006 JFM season rainfall was frequently surpassing the OND. Hence, it is clear evidence of change in the rainfall pattern in the region. As far as periodical rainfall distribution is concerned, April to June (AMJ) can be reckoned as third whereas, JAS receive least rainfall (see Figure 4.6) clearly pointing out that the month of July marks the start of rainfall cessation. The years 1992, 1999, 2002 and 2015 fell below the mean average of 482mm per annum as shown in Table 3.

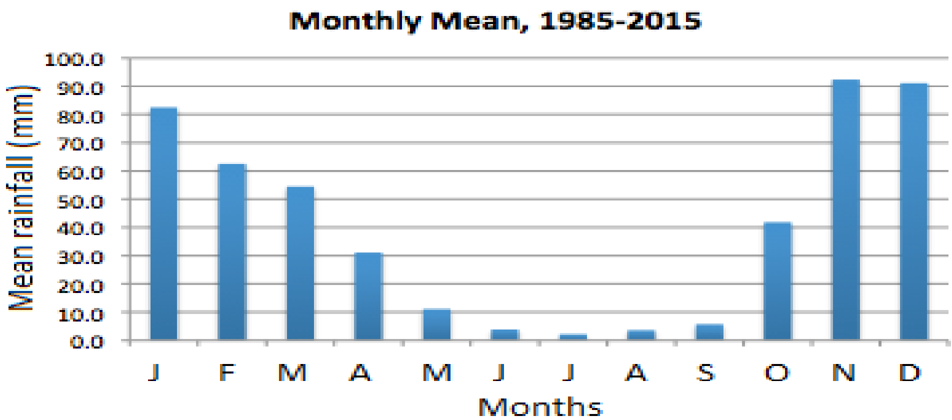


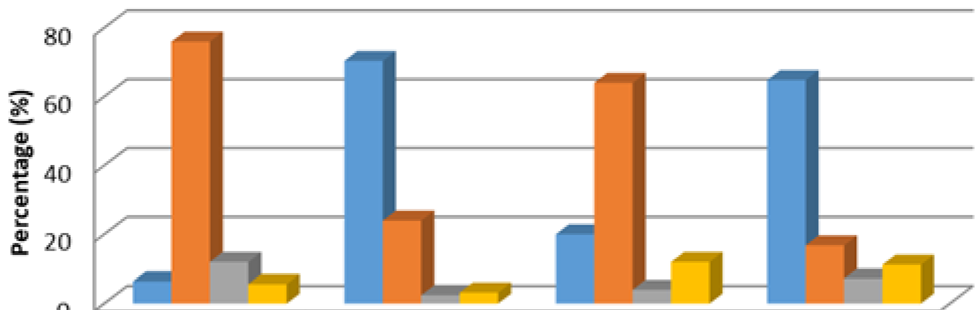
Figure 4.6. Monthly mean rainfall (1985-2015)

4.4 Farmers' perceptions on climate variability

4.4.1 Farmer's perceptions of rainfall and temperature variability

This section dealt with farmers' perceptions on climate variability based on what they observed over the years they lived in their respective area. Farmers were asked how the weather had changed over the years, and what variation they had observed over the past decade or two. Aspects that were checked on comprise such things as how temperatures varied in winter and summers, times when rainfall began and ceased and a check on whether rainfall and temperature supported crop production.

Using the Likert scale to assess farmers' perceptions on climate variability (Figure 4.7) 76% of the farmers in the study area indicated that there was a decrease in amount of rainfall, while 6% instead observed an increase. Twelve percent reported no change, while another 6% were unsure. With regards to the number of rainy days, 64% reported a decrease, while 20% felt there was an increase. Twelve percent were unsure of any change in number of rainy days while only 4% reported no change. A majority of farmers (70%) felt there was an increase in temperature while 24% reported a decrease. Farmers' responses on temperature variability were consistent with perceptions of dry spells, with 65% reporting an increase in dry spells. A decrease in frequency of dry spells was reported by 17%, whereas 7% felt there was no change while 11% was not sure.



	Rainfall	Temperature	Number of Rainy Days	Dry Spells
Increased	6	70	20	65
Decreased	76	24	64	17
No Change	12	2	4	7
Not Sure	6	3	12	11

Figure 4.7. Farmers' perceptions on climate variability.

Most of the farmers (97%) reported that the onset of the rainy season had shifted from around October to end of November and early December. About 98% of interviewed farmers reported that there has been a change in the start and end of the rainy season, over past five years. There was a general consensus on the fact that climatic conditions had become more erratic over the past 5 years. During the FGDs, the farmers revealed that the rainy season ended as early as the beginning of March unlike in the past when rainy seasons ended at the beginning of April. One farmer in his late 60s indicated that in during his teens, effective rains used to start early in the month of October, but nowadays, the rainy season starts at the end of November or even in December.

The main concerns raised by the farmers was the effects of the unpredictability weather patterns on their agricultural activities. Some farmers noted that over a decade ago rainfall distribution over the season was *normal* (implying sufficient and predictable) and they could plan their agricultural activities appropriately and effectively. Applying similar patterns of planning have proved abortive and fruitless, often times resulting in financial loss.

Another concern emanating from FGDs was regarding the spatial distribution of rainfall over in the province in general and Botlokwa Village in particular. Farmers made allusions to experiencing uneven distribution of rainfall, with some settlements receiving rainfall, whilst the neighbouring villages or communities were experience no indication of rainfall during the same time frame.

4.4.2 Comparison of farmers' perceptions of climate variability with climatological data

Comparisons were restricted to the past 5 to 10 years, as such only rainfall and temperature data for the period 2006 – 2015 were used to assess farmers' perception of climate variability. With respect to rainfall variability, interview data indicated that there was a decrease in total annual rainfall (Figure 18) over the selected period. The responses of farmers were consistent with their observations of increased dry spells. The farmers' claims of decreased rainfall were equally supported by uneven distribution of rainfall events within the study area, with some communities receiving precipitation while others did not.

Visual comparison with rainfall trends for 2006 – 2015 were in agreement with farmers' perceptions. Despite occasional spikes in 2006 (678 mm) and 2013 (636 mm), there was a general decline in annual rainfall compared to the previous decade. The period 2013 – 2015 was characterised by a sharp decline, with 2015 recording the lowest annual rainfall (296 mm), only second to 2001 (257 mm) over the 30-year period. The trends in both annual minimum and maximum temperatures showed a clear increase, which corroborated with the farmer's perceptions of increased temperature, including frequency of dry spells .

Farmers in the study area used the term *poor season* to refer to any year with reduced crop production due to unsatisfactory rainfall and other crop production constraints. The farming seasons 2006/2007 and 2014/2015 were considered the worst seasons by the farmers. Their characterisation of the 2006/2007 farming season as a *poor season* (implying unsatisfactory/insufficient amount of rainfall) however contradicted the climatological evidence which portrayed 2006/2007 as years with peak rainfall .The reason for experience a poor farming season may be attributed to timing of seeding, which is informed by proper appraisal of onset, cessation and length of rainy season. Conversely, farmers' observation of 2014/2015 as farming seasons which received the least rainfall was consistent with climatological evidence.

Perceptions of climate, according to Slegers (2008), are based on the livelihood impacts the climate has on individual farmers, (that is, the social and economic impacts). In this study, any season that negatively affected the farmers' livelihoods was described as poor. For example, the length of the dry spell was a major constraint in relation to crop failure as revealed by the farmers during the 2006/2007 season. In this season, 678 mm of rainfall was received, which climatologically can be classified as above average, but was characterised by long dry spells in the month of February 2007 (9.2 mm) and was therefore classified as poor by the farmers.

The information on crop yield expectations helps inform us that farmers do not necessarily consider poor seasons strictly in meteorological terms. Even those seasons that might have a good rainfall distribution and above average rainfall (in terms of climate data) can be termed "poor" by farmers. This is partly an indication that for farmers, when evaluating cropping seasons, any problem that limits harvests leads to a bad season. The yield levels or expectations of the yield are mostly the ones that determine how to describe a season.

A cross tabulation between the sampled farmers' age and the farmers' perceptions of climate variability explained that majority of farmers who perceived variability in climate were in the age group between 30-40 (28%), 41-50 (40%)and 51-60 years (17%), compared to farmers below the age of 30 years (7%) or above the age of 60 years (8%).

Regarding patterns of precipitation, 51% of farmers in the age group 30-60 years agreed that they had observed changes in the timing of rains, compared to 4% and 6% of the farmers in the age groups below 30 years and above 60 years, respectively. The reason being that farmers younger than 30 years do not have extensive farming experience and those above age 60 are not as focused as they used to be.

With regards to the farming experience, the study found out that the majority (83%) of farmers who perceived climate variability had high farming experience (above 10 years) compared to 11% who had low farming experience (5-10 years). As 51% of the farmers with high farming experience observed that there was considerable variation in the levels of temperature, only 6% of farmers with low farming experience indicated to have noticed variation in temperature levels. Farm size was not a factor on how farmers perceived climate variability as compared to existing climatological data.

The study further established that most farmers who perceived climate variability had attained post primary (61%) education compared to 33% who had up to primary education.

4.5 Farmers' adaptation strategies to climate variability

In response to the impacts associated with climate variability, farmers in the study areas reported to have taken different adaptation measures. Previous studies suggest that to improve estimates of climate impacts on agricultural systems and contribute efficiently to adaptation research, there is a need to know more about how farmers perceive climate and how they respond, in both the short- and long-term, to variable climate conditions, including the magnitude and frequency of extreme conditions (Smit et al., 1996). Moreover, literature on adaptation also makes it clear that perception studies are necessary for implementation of adaptation strategies (Maddison, 2006). Thus, some studies in Africa (Gbetibouo, 2009 and Maddison, 2006; Moyo et al., 2012; Simelton et al., 2013) have suggested that the success of any adaptation measure would depend on a farmers' perception about climate variability. Several adaptation strategies were undertaken by farmers and the relative importance of adaptation strategies to climate variability was calculated based on the Weighted Average Index (WAI) and Adaptation Strategy Index (ASI) (Table 4.4). The main adaptation strategies employed by the farmers in the area by decreasing importance included; (1) use of indigenous knowledge, (2) Crop management (crop diversification > use of different planting dates > soil conservation, mulching and manure), and (3) water management (increase irrigation systems). A change from crops to livestock followed by reduction in farm size, relocation to different sites (or village), use of insurance and subsidies were the least adopted options respectively.

Table 4.4. Adaptive strategies Weighted Average Index (WAI) and ranking

Adaptive strategy		Level of Importance					
		High	Meduim	Low	No	WAI	Rank
Crop management	Crop diversification	85	25	3	12	3.46	2
	Use different planting dates	60	46	8	11	3.24	4
	Plant different varieties	72	32	2	19	3.26	3
	Shorter growing periods	10	16	77	22	2.11	11
	Soil conservation, mulching and manure	66	33	15	11	3.23	5
	Change use of fertilizers and pesticides	62	28	18	17	3.08	7
Soil fertility management	Move to different site (or village)	10	6	33	76	1.60	13
	Change land size	14	23	20	68	1.86	12
	Change from crops to livestock	33	37	5	50	2.42	10
	Change from farming to non-farming	55	15	5	50	2.60	9
	Use insurance	5	7	5	108	1.27	14
	Use subsidies	4	3	1	117	1.15	15
Water management	Increase irrigation system	63	25	22	15	3.09	6
	Change water conservation practice	72	13	10	30	3.02	8
Use of Indigenous Knowledge	If Yes (87)= 70%	62	15	10	0	3.54	1

4.5.1 Indigenous knowledge

Out of 15 adaptation strategies, the use of indigenous knowledge was ranked first (70% respondents) and thus most important, among farmers' adaptive strategies to climate variability. In Sub-Saharan Africa, however, there is limited access to climate information and relatively low capacity to meaningfully utilize the provided information that farmers have access to (Dutta, 2009; Odendo et al., 2006). Farmers, therefore, tend to rely on indigenous knowledge and information from local social networks to make decisions and manage technology related risks and climate variability (Nyong et al., 2007). More recent studies have shown that resilience building for smallholder farmers in Africa is a process that starts with the ability to anticipate change and accordingly adjust farming practices and set the base for sound food security, particularly in the context of climate variability.

During the FGD one farmer indicated that indigenous forecast of the weather tends to be more accurate for them and easier to understand than the complex scientific forecast. He further mentioned that,

> "*The scientific forecast tends to be more sophisticated, needs formal education and extensive financial investments*".

The farmers in the study area are mostly interested in when the rainy season will start so they can prepare and in the quality of the season so that they can decide what to grow. Farmers use tree phenology, animal behaviour, wind circulation, cloud cover and other social indicators to predict rains and season quality. Table 4.5 below discusses some of the indigenous knowledge adaptation practices that small scale farmers in Botlokwa Village rely on.

4.5.2 Crop diversification, planting different crop varieties and use of different planting dates

A study conducted in Ghana showed that diversifying crop type and changing crop planting dates were identified as the major adaptation strategies to a warmer climate (Badmos et al., 2015). Similarly, in this current study, respondents appeared to have changed their crop management in response to declining precipitation, with crop diversification and shifting planting dates being the most important adaptation measures.

Table 4.5. Indigenous practices employed as adaptive strategies to climate variability

Superordinate theme	Emerging themes
Use of animals	Army worms followed by heavy rains it means there will be good harvest. Army worms followed by little or no rain, represents famine or a poor season. When goats and sheep have high mating libido between August and October that predicts more rain. Red ants (mostly on ant hills) during the months of November and December, it represents more rain to come and the farmer prepares to sow seeds.
Observation of the sky (clouds)	If the rainbow shows more of the colour red during June/July, then there will be more rain during the rainy season. Instead, more of the blue colour represents a dry season. At around 3-5pm during the months of June and July, a star natively known as *Sekgopetjane* is usually showing towards the west, then the prediction is that there will be sufficient rain during the rainy seasons to follow.
Consultation of fortune tellers	Some locals consult with the local traditional fortune teller (*ngaka/nkadingala*) who can foresee the future by throwing bones and performing rituals consulting with the ancestors.

The farmers in the study area reported that rainfall characteristics in terms of length of growing season have always been uncertain due to high variability of the onset and cessation of the rainy season. In some years the rains start early while in others they arrive late. Hence, the inter-annual variability makes it difficult to determine the sowing date, the selection of the crop type and crop varieties. The farmers in Botlokwa Village reported that they do not rely on one crop type but a variety of crops such as maize (main type), peanuts, beans and watermelons.

4.6 Influence of household characteristics on adaptation strategies

4.6.1 Age and gender

The study revealed that most farmers (71%) who adapted to climate variability were in the age group between 30-40, 41-50 and 51-60 years. Only a handful, 6% and 8%, were in the age group below 30 years and above 60 years, respectively. Moreover, most farmers in the age group between 30 and 60 years adapted to changes in temperature and precipitation using various methods. The most popular adaptation methods were growing varieties of crops (54%) and using different planting dates (64%). The least popular adaptation strategies were switching from non-farming to farming (6%) and the change use of fertilizers and pesticides (5%). As for sex, males (78%) adapted more than females (28%), with changing from crops to livestock (80%), changing from farming to non-farming (77%) and Increase irrigation system (62%).

4.6.2 Level of education

As for the education level, the study established that majority (63%) of the farmers who adapted in various ways to variation in temperature and precipitation had reached post primary (secondary and higher education) education when compared to those who had up to primary level education (22%). The most common adaptation strategies among farmers having post primary education, besides growing different crops (50%) and changing land size under cultivation (50%), were diversifying crops (43%) and migrating to a different site (44%). The least common methods of adaptation, other than switching from non-farming to farming (7%) and the increased use of irrigation (6%), was switching from livestock to crop farming (8%).

4.6.3 Farming experience

In relation to farming experience, the study found out that majority (64%) of the farmers who adapted to climate variability had farming experience of more than 20 years in comparison to 11-20 (25%) and 11% of the farmers who had low experience of about 10 years and below. Among the common adaptation strategies for farmers with more farming experience included: growing different crops (56%), changing land (56%), diversifying crops (49%), growing different crop varieties (46%), shortening growing periods (46%) and increasing irrigation systems (45%). However, the increased use of fertilizers and pesticides (20%), switching from non-farming to farming (8%) and changing of water conservation practice (8%) were some of the adaptation methods that were least employed by the highly experienced farmers.

4.6.4 Access to information on climate variability

In the study area, there were no extension workers, and farmers could not access extension service including both private and public service. Besides, the ways to transfer technology of agricultural staff were only without practicing and short time. This led to many difficulties for farmers in the study area to adapt to new techniques especially applying mineral fertilizers for crops. All the respondents interviewed either had access to media or indigenous knowledge. In the study area, Botlokwa, at least 54% of the respondents preferred to use external climate forecast sources. Farmers believed that external forecasting could add value and profit to their farming business by facilitating correct decisions and management strategies. All the respondents interviewed in Botlokwa had a radio, so access to external forecasting, relating to both daily weather forecasts and seasonal climate information, did not seem to be a problem if the information was made available through the radio stations.

The use of more than one communication system, including newspapers such as Mirror, Sowetan, Citizen, Daily Sun, Sunday Times and City Press newspapers and radio stations including, Botlokwa FM and Thobela FM and the South African Broadcasting Corporation (SABC) could facilitate dissemination. Unfortunately, few people can read newspapers, which may be due to high levels of illiteracy. Some other forms of communication that could be useful for disseminating climate information include telephones. In relation to age and level of education, farmers that are aged >60 made 90% of the respondents that agreed to have been relying on indigenous knowledge, while the rest of the 10% are those farmers who had no education.

4.7 Farmers' perceptions on climate variability and implications for coping/adaptation strategies

As shown in Figure 4.8, most of the farmers in Botlokwa Village indicated that climate forecast information should be disseminated at least before the beginning of the season, either through the local radio stations or electronic print media. This is the time when most of the farmers are starting to prepare seeds, fertilizers and herbicides. Timing and distribution of seasonal forecasts is critical for farmers. The most popular time to receive a seasonal forecast is September.

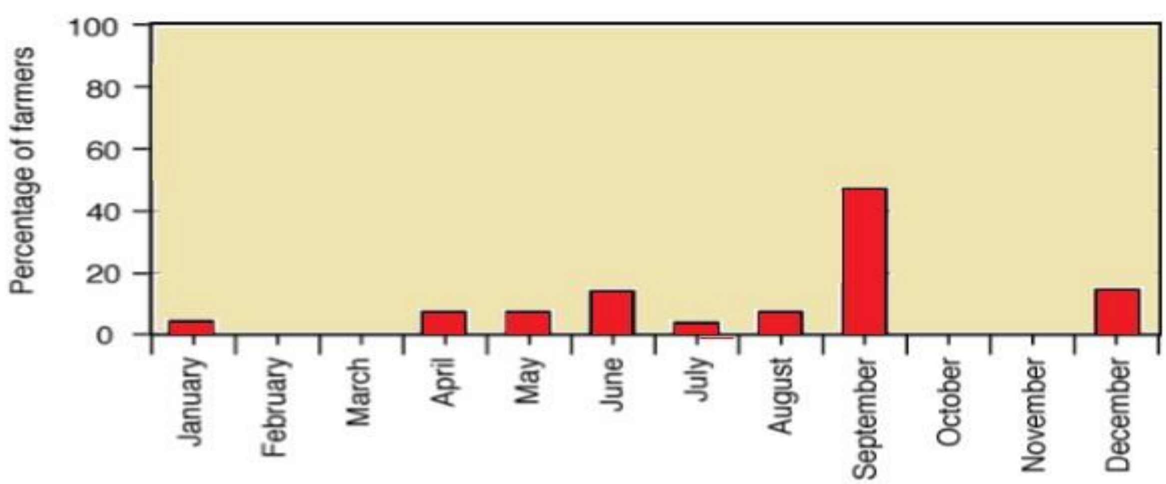


Figure 4.8. Preferred months by farmers from Botlokwa Village to receive weather forecast

Eight percent (8%) of the respondents preferred to have information on climate forecasting in August. They indicated that these were the months during which they tried to produce different varieties of crops as part of their risk management strategies. These strategies assist them to generate extra sources of income when most of the farmers are waiting to harvest their existing crops. Some of the farmers in the area indicated that August was important, because if they had climate forecast information in their possession they would be able to take correct decisions on whether to plant drought-tolerant crops or not. Some farmers stated that this was the time (August and September) when the majority actually needed climate information because this could assist them to know what to expect at the end of the season.

As indicated earlier, most of the farmers in the area used traditional knowledge in their farming business that has been sustained over time, being inherited from their grandparents and that has become a system of knowledge to help farmers during times of climate stress. Since scientific climate forecasting was introduced to these farmers, the majorities have, however, begun combining local knowledge forecasting and external knowledge forecasts to reduce risk and increase production. Despite the awareness and use of scientific forecasts there is still reluctance, however, to replace this form of knowledge in favour of local knowledge. Some farmers stated that it is difficult for them to abandon local knowledge in favour of scientific knowledge completely. The fact that external climate forecasts can provide additional valuable information for crop management, planting time and the choice of cultivars, some (especially young farmers) have started to use and apply technically-derived forecast information to their decision making.

Majority of the farmers stated that since they were farming in a semi-arid area where the climatic condition was always variable, they had no choice but to use hybrid seeds to obtain good production. In the area only 52% of the farmers use hybrid seeds. Less than 45% of the farmers' areas prefer to use both traditional and hybrid seeds together as part of adaptation strategies against periods of climate stress. The fact that most of the farmers prefer to use hybrid seeds is due to the following reasons:

- To increased yield per hectare.
- The seeds are drought-resistant.
- Resistance to diseases and pests.

It was also observed that majority of farmers in all the area are still planting other heat sensitive crops such as watermelons and sweet potatoes. This is one of the reasons why during poor seasons majority of the farmers suffer high losses of production, because only small numbers of farmers are using drought-resistant crops as part of their coping strategies.

The findings from the analysis and discussions in this chapter conclude that the local knowledge of Botlokwa small holder farmers on climate variability is fundamental to enhancing the adaptive capacities of these farmers, who show differences in preferences for adapting. Ideas seen in the context of existing practices of farmers can be easily accepted and embraced by farmers. Since farmers use their perceptions to make decisions on coping and adapting, through local knowledge, policy makers can understand what smallholders perceive and adapt to, before they design policies on how best to prepare and respond to climatic variability. Adaptation policies that integrate farmers' knowledge will improve smallholders' agriculture through promotion of farmer friendly adaptations. Estimated results indicated that climate variables of temperature and precipitation are very relevant for agricultural activities in the study area and especially with respect to precipitation.

The use of seasonal climate forecasts is already helping farmers and could help farmers even more to manage climate risk mainly rainfall, onset and cessation date variability, if such forecast where more timely and targeted (Roncoli et al.,2012).

CHAPTER FIVE: CONCLUSIONS AND RECOMENDATIONS

5.1 Introduction

This chapter provides a summary of findings, highlights the conclusion based on the objectives of the study and ends up with recommendations on enhancing adaptive capacity of smallholder farmers in Botlokwa Village.

5.2 Summary of findings

This research has attempted to characterize the understanding of climate variability in the context of local perceptions, historical climate data, coping and adaptation strategies from the perspective of Botlokwa Village smallholder farmers. Farmers' memory of past events can be unreliable as well as their uncertainty to differentiate between climate (the statistical expectation) and weather (what we get) patterns. This becomes problematic when investigating climate variability as farmers may need to use personal experience, which could be unreliable. Rationally, farmers prefer to learn from experience instead of statistical descriptions, which may lead to flawed interpretation.

In this study on semi-arid Botlokwa Village, farmers' expectations, more than statistical information influenced farmers' perceptions on climate variability as evidenced by the contradictions between the farmers' perceptions and the official meteorological data, especially the rainfall received from the 2006/7 season.

The current study does agree with some studies that indicate that climate variability is real though studies on the long-term climatological data, especially that of rainfall patterns in semi-arid Africa have not confirmed this (Scoones, 2004; Slegers, 2008). Osbahr et al. (2011) argued that there is nothing wrong with farmer perceptions as these may be social constructs but they usually have a statistically low correlation with climatology data. In concurrence with Ferrier and Haque (2003), the study showed that farmers remember the extremes in climate and they also remember the recent events (years) with reduced crop productivity. The recall by farmers of the extremes in weather has been described by

Osbahr et al., (2011) as being consistent with human behaviour (human perception and memory) so as it in the current study.

The study also revealed that farmers were more concerned about within season rainfall variability, than inter-seasonal variation which seemed to be the major factor constraining semi-arid agriculture, a finding documented by Recha et al. (2008). Thus, long-term planning becomes a challenge. The analysis of long term rainfall data (30 years) revealed that there were large intra- and inter-season variations in the study area. The study found both farmers and climatological data reporting an increase in temperatures. However, the farmers may be reporting overall rainfall decline, which could be attributed to temperature increases.

The views of the farmers suggested that people's perceptions and their agricultural practices provide insights to what smallholders really need and prefer in adapting their agriculture to climatic variability. Smallholders' knowledge pointed out what needed to be improved to enhance adaptive capacity. The results from the study also showed that the age of the household head, gender, level of education, farming experience and access to information on climate variability were crucial factors in influencing the likelihood of farmers to perceive climate variability.

The most common adaptation strategies among farming households who perceived increases in temperature were: use of indigenous knowledge, crop diversification, planting different crops and use of different planting dates. On the other hand, adaptation measures least employed by farmers who perceived changes in temperature included: switching from crops to livestock, switching from farming to non-farming and change use of fertilizers and pesticides.

Farmers who noted a decrease and timing of rains, a majority opted to use different planting dates, shorter growing periods and crop diversification. The least popular adaptation methods among all farmers who either noted a decrease in precipitation or a variation in timing of rains were switching from farming to non-farming and the use of irrigation technology due to scarcity of irrigation water.

5.3 Conclusions

Farmers' expectations influenced farmers' perceptions on climate variability as evidenced by the contradictions between the farmers' perceptions and the official meteorological data. In particular, the rainfall received from the 2006/7 season and their views suggested that perceptions and agricultural practices provide insights to what smallholders really need and prefer in adapting their agricultural practises to climatic variability.

5.4 Recommendations

Most of the farmers in Botlokwa Village, due to their rural undying culture use indigenous knowledge as one of their major adaptive strategy, therefore more research on local knowledge forecasting is needed in order to validate the usefulness of local knowledge, strategies for integrating local knowledge must be developed as soon as possible and there is a need to develop a strategy to test and monitor local indicators such as the behaviour of animals, the atmosphere (e.g. cloud formation), behaviour of wind, and the characteristics of plants and trees.

- Local knowledge forecasting and its methods should be incorporated in all the projects and programmes as strategies to encourage researchers, academics and extension officers to start recognizing local knowledge forecasting in the area. All these stakeholders should collaborate with local communities as part of capacity building and technology transfer.

- It was also discovered in the study that farming in the area was also carried out by women who relied on the activity for survival. This has important policy implication in that women in this area would therefore need to be empowered through women groups and associations since this can have significant positive impacts for increasing the uptake of adaptation measures by the farmers.

- There is increasing usage of cellular phones and these media sources could be probed in future Early Warning Systems. Agricultural extension officers Extension, SAWS, and various institutions could assist local farmers by trying to ensure that a forecast for the season becomes available by September, with options for mid-season corrections of forecasts to enable other farming options across the area. Farmers in the study area indicated that if they had external forecast information in advance, it would be easy to decide on what type of seeds or crop cultivars.

REFERENCES

Acquah H., de-Graft H, Onumah E. E. 2011. AGRIS on-line Papers in Economics and Informatics, 3 (4): 34 – 44.

Adams, R., B. Hurd, S. Lenhart and N. Leary. 1998. Effects of Global Climate Change on Agriculture: An Interpretative Review. Climate Research 11: 19-30.

Adger, W N., Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D. R. Nelson, L. O. Naess, J. Wolf, Wreford, A. 2009. Are there social limits to adaptation to climate change? Climatic Change 93:335-354.

Adger, W.N., 2003. Social aspects of adaptive capacity. In J.B., Smith, R.J.T., Klein and S., Huq (Eds.), Climate Change, Adaptive Capacity and Development, 29–49. Imperial College Press, London

Adger, WN, Arnell, N.W. and Tompkins, E.L., 2005. Successful adaptation to climate change across scales. Global Environmental Change, 15: 77–86.

Adger, W.N., Kelly, P.M. and Ninh, N.H. (Eds.), 2001.Living with Environmental Change: Social Resilience, Adaptation and Vulnerability in Vietnam.Routledge, London, UK.

Adosi, J. 2007. Climate Change Related Vulnerability, Resilience and Adaptation in Tanzania. Tanzania Meteorological Agency. Dar es Salaam. 46pp.

Alreck, P.L, Settle, R.B. (1995) The Survey Research Handbook, 2nd edition. Chicago: Irwin.

Amadou, M. L., Villamor, G. B., Attua, E. M., & Seydou, B. T. (2015).Comparing farmers' perception of climate change and variability with historical climate data in the Upper East Region of Ghana 28p. Retrieved from http://www.ajol.info/index.php/gjg/article/view/126290

Apata T.G, Samuel K.D and Adeola A.O (2009).Analysis of climate change perception and adaptation among arable food crop farmers in South West Nigeria. Contributed paper prepared for presentation at International Association of Agricultural Economists' 2009 conference, Beijing, China.

Asfaw A, Admassie A (2004). The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. Agric. Econ. 30:21-22.

Badmos, B.K., Villamor, G.B., Agodzo, S.K., Odai, S.N., Guug, S. S. (2015) Examining agricultural land-use/cover change options in rural Northern Ghana: a participatory scenario exploration exercise approach. J. Interdiscip. Environ.

Badolo, F., Kinda S. R. 2014.Climatic Variability and Food Security in Developing Countries.Working Paper halshs-00939247.HAL.http://ideas.repec.org/p/hal/wpaper/halshs-00939247.html.

Bandyopadhyay, S., L. Wang, and M. Wijnen. 2011. Improving household survey instruments for understanding agricultural household adaptation to climate change: water stress and variability. Living Standards Measurement Study - Integrated Surveys on Agriculture, Washington, D.C., USA.

Bello, M., Salau, E. S., Galadima, O. E., & Ali, I. (2013). Knowledge, perception and adaptation strategies to climate change among farmers of Central State Nigeria. Sustainable Agriculture Research, 107-117. http://dx.doi.org/10.5539/sar.v2n3p107

Benhin JKA, 2006. Climate change and South African Agriculture.CEEPA Discussion Paper No. 21 Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Benhin, JKA. 2008. South African crop farming and climate change: An economic assessment of impacts. Global Environmental Change, 18: 666-678.

Berkes, F., and D. Jolly. 2002. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. Conservation Ecology 5(2): 18.

Berkhout, F., Hertin, J. and Gann, D.M., 2006.Learning to adapt: Organisational adaptation to climate change impacts.Climatic Change, 78(1).

Bhushal, Y. (2009). Local people's perceptions on climate change, its impacts and adaptation measures in mid-mountain region of Nepal. A case study for Kaski district.BSc thesis, Tribhuvan University, Nepal.

Bishaw, Badege, Henry Neufeldt, Jeremias Mowo, Abdu Abdelkadir, Jonathan Muriuki, Gemedo Dalle, Tewodros Assefa, Kathleen Guillozet, Habtemariam Kassa, Ian K. Dawson, Eike Luedeling, and Cheikh Mbow. 2013. Farmers' Strategies for Adapting to and Mitigating Climate Variability and Change through Agroforestry in Ethiopia and Kenya, Forestry Communications Group, Oregon State University, Corvallis, Oregon.

Boissière, M., B. Locatelli, D. Sheil, M. Padmanaba, and E. Sadjudin. 2013. Local perceptions of climate variability and change in tropical forests of Papua, Indonesia. Ecology and Society 18(4): 13. http://dx.doi. org/10.5751/ES-05822-180413

Boko M, Niang I, Nyong A, Vogel C, Githeko A, Medany M, Osman-Elasha B, Tabo R and Yanda P. 2007. Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry M L, Canziani O F, Palutikof J P, van der Linden P J and Hanson C E (eds). Cambridge University Press.Cambridge UK. pp. 433 – 467.

Bradshaw, B., Dolan, H., Smit, B., 2004. Farm-level adaptation to climatic variability and change: crop diversification in the Canadian prairies. Climatic Change 67, 119–141

Brondizio, S. and Moran, E.F. (2008). Human dimensions of climate change: the vulnerability of small farmers in the Amazon. Philosophical Transactions of the Royal Society Biological Sciences, 363: 1803-1809.

Bryan, E., T.T. Deressa, G.A. Gbetibouo, and C. Ringer. 2008. Adaptation to climate change in Ethiopia and South Africa: Options and constraints. Environmental Science & Policy 12: 413–426.

Bryant, C. R., Smit, B., Brklacich, M., Johnston, T. R., Smithers, J., Chiotti, Q. & Singh, B. (2000) Adaptation in Canadian agriculture to climatic variability and change.Clim. Change 45, 181– 201. The Netherlands: Kluwer Academic Publishers.

Bryant, E., T.T. Deressa, G.A. Gbetibouo, and C. Ringler. 2009. Adaptation to Climate Change in Ethiopia and South Africa: Options and Constraints. Environmental Science and Policy 12: 413-426.

Centre for Environmental Economics and Policy in Africa (CEEPA). 2006. Climate change and African agriculture. Ceepa Policy Note No. 25, University of Pretoria, Pretoria.

CFU.(2006). Reversing Food Insecurity and Environmental Degradation in Zambia through Conservation Agriculture. Lusaka: Conservation Farming Unit.

Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.T., Laprise, R., Magana Rueda, V., Mearns, L., Menendez, C.G., Raisanen, J., Rinke, A., Sarr, A. and Whetton, P. (2007). Regional climate projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel

Conway, D., Allison, E., Felstead, R. and Goulden, M., 2005. Rainfall variability in East Africa: Implications for natural resources management and livelihoods. Philosophical Transactions of the Royal Society: Mathematical, Physical and Engineering Sciences, 363(1826): 49–54.

Cooper, P. J. M., J. Dimes, K. P. C. Rao, B. Shapiro, B. Shiferaw, and S. Twomlow. 2008. Coping better with current climatic variability in the rain-fed farming systems of subSaharan Africa: an essential first step in adapting to future climate change? Agriculture, Ecosystems & Environment 126 (1-2):24-35.

Couzin, J. 2007. Opening doors to native knowledge. Scientific and local cultures seek common ground for tackling climate-change questions in the Arctic. Science 315:1518-1519. http://dx.doi.org/10.1126/science.315.5818.1518

Croppenstedt , A., M., Demeke and M.M., Meschi (2003). Technology Adoption in the Presence of Constraints: the Case of Fertilizer Demand in Ethiopia. Review of Development Economics, 7(1): 58- 70.

Davies, S. 1993. Are coping strategies a cop out? IDS Bulletin 24(4):60-72

Debela N, Mohammed C, Bridle K, Corkrey R, McNeil D. (2015). Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, South Ethiopia. SpringerPlus, 4(236):1–12.

Deressa, T., Hassan, R. M., Alemu, T., Yesuf, M., & Ringler, C. (2008). Analysing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia, IFPRI Discussion Paper 00798: International Food Policy Research Institute

Deressa, T.T., R.M. Hassan, and C. Ringler. 2011. Perception of and Adaptation to Climate Change by Farmers in the Nile Basin of Ethiopia. The Journal of Agricultural Science 149: 23-31.

Deressa, T.T., R.M. Hassan, C. Ringler, T. Alemu, and M. Yesuf. 2009. Determinants of Farmers' Choice of Adaptation Methods to Climate Change in the Nile Basin of Ethiopia. Global Environmental Change 19: 248-255.

Dilley, M. 1999 Reducing vulnerability to climate variability in Southern Africa: The growing role of climate information. USAID Office of US foreign disaster assistance. Washington DC, USA.

Downing, T.E. and Patwardhan, A., with Klein, R.J.T., Mukhala, E., Stephen, L., Winograd, M. and Ziervogel, G., 2005.Assessing vulnerability for climate adaptation. In Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. Lim, B., Spanger-Siegfried, E., Burton, I., Malone, E. and Huq, S. (Eds.). Cambridge University Press, Cambridge.

Du Toit, A., 2002. Globalizing ethics: Social technologies of private regulation and the South African wine industry.Journal of Agrarian Change, 2(3), pp.356-380.

Dutta, R. (2009). Information needs and information-seeking behaviour in developing countries: A review of the research. International Information and Library Review, 41, 44-51. http://dx.doi.org/10.1080/10572317.2009.10762796

DWAF. 2004. National Water Resource Strategy, First Edition. Available at: www.dwaf.gov.za/documents/.

Eriksen, S. and J.A. Silva, 2009: The vulnerability context of a savanna area in Mozambique: household drought coping strategies and responses to economic change. Environmental Science and Policy, 12(1), 33-52.

FAO (Food and Agriculture Organisation). 2008. Climate Change and Food Security: A Framework Document. Rome: FAO-UN.

FAO. (2009). Conservation Agriculture Scaling Up for Increased Productivity and Production.http://www.norway.org.zm/Embassy/norwayzambia/Project-Archives/ConservationAgriculture (May 09, 2016)

FAO. (2011b). Socio-Economic Analysis of Conservation Agriculture in Southern Africa. Rome: Food and Agriculture Organisation of the United Nations.

Ferrier, N. and Haque, C.E. 2003. Hazard risk assessment methodology for emergency managers: a standardised framework for application. Natural Hazards 28:271-290.

Floyd DL, Prentice-Dunn S, Rogers RW (2000) A meta-analysis of research on protection motivation theory. J Appl Soc Psychol 30(2):407–429

Funk, C., Michaelsen, J. and Marshall, M. (2012).Mapping recent decadal climate variations in precipitation and temperature across Eastern Africa and the Sahel. In: Remote Sensing of Drought: Innovative Monitoring Approaches [Wardlow, B.D., M.C. Anderson, and J.P. Verdin (eds.)]. CRC Press, Boca Raton, FL, USA, pp. 331 – 358.

Fussel, H.M, R.J.T. Klein, K.L. Ebi, and B. Menne. 2006. Adaptation Assessment for Public Health. In Climate Change and Adaptation Strategies for Human Health, edited by B. Menne and K.L. Ebi. Darmstadt, Germany: Steinkopff Verlag, 41–62.

Galvin, K.A., Boone, R.B., Smith, N.M., Lynn, S.J. 2001. Impacts of climate variability on East African pastoralists: Linking social science and remote sensing. Climate Research, 19(1), 161–172.

Gbetibouo, G., Hassan, R. 2005. Economic impact of climate change on major South African field crops: A Ricardian approach. Global and Planetary Change, 47: 143–152.

Gbetibouo, G.A. 2009. Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. IFPRI Discussion Paper 00849. http://www.ifpri.org/sites/default/files/publications/rb15_08.pdf.[2016, November 05]

GoLimpopo.Com, "Limpopo Facts Overview," last accessed May 2015. http://www.golimpopo.com/facts-overview

Grab, S. and Craparo, A. (2011). Advance of apple and pear tree full bloom dates in response to climate change in the South Western Cape, South Africa: 1973 – 2009. Agricultural and Forest Meteorology, 151(3): 406 – 413.

Grothmann T, Patt A. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. Global Environmental Change Part A, 15:199–213.

Grothmann, T., and A. Patt. 2005. Adaptive capacity and human cognition: the process of individual adaptation to climate change. Global Environmental Change 15:199-213.

Gwimbi, P. 2009 Cotton farmers' vulnerability to climate change in Gokwe district (Zimbabwe): Impact and influencing factors. JAMBA: Journal of Disaster risk studies. Volume 2 No.1.Department of Environmental Health, National University of Lesotho.

Gyampoh, B.A., Idinoba, M. & Amisah, S. 2008. Water scarcity under a changing climate in Ghana: options for livelihoods adaptation. Development, 51: 415–417.

Hansen, J., S. Marx, and E. Weber, editors. 2004. The role of climate perceptions, expectations, and forecasts in farmer decision making: the Argentine Pampas and South Florida. International Research Institute for Climate and Society, Palisades, New York, USA.

Hansen, J., S. Marx, and E. Weber, editors. 2012. The role of climate perceptions, expectations, and forecasts in farmer decision making: the Argentine Pampas and South Florida. International Research Institute for Climate and Society, Palisades, New York, USA.

Hassan, R and Nhemachena, C. 2008. Determinants of African farmers' strategies foradaptation to climate change: Multinomial choice analysis. African Journal of Agricultural and Resource Economics, Vol 2 No. 1 March 2008.

Hassan, R., and C. Nhemachena. 2008. Determinants of African Farmers' Strategies for Adapting to Climate Change: Multinomial Choice Analysis. African Journal of Agricultural and Resource Economics 2: 83-104.

Hazell P, Poulton C, Wiggins S and Dorward A (2007).The Future of small farms for poverty reduction and growth. International Food Policy Research Institute (IFPRI) 2020 Discussion Paper 42, IFPRI.Washington D.C.

Hewitson, B.C., and Crane, R.G., 2006. Consensus between GCM climate change projections with empirical downscaling: Precipitation downscaling over South Africa, International Journal of Climatology. 26(10): 1315–1337

Hoffman, M.T., Cramer, M.D., Gillson, L. and Wallace, M. (2011). Pan evaporation and wind run decline in the Cape Floristic Region of South Africa (1974 – 2005): implications for vegetation responses to climate change. Climatic Change, 109(3 – 4): 437 – 452

Imai, K., 2003. Is livestock important for risk behaviour and activity choice in rural households? Evidence from Kenya. Journal of African Economies, 12: 271–295.

Intergovernmental Panel on Climate Change (IPCC). 2001. Climate Change 2001: Impacts, Adaptation Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: University Press.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPPC. Cambridge, UK: Cambridge University Press, 869-883.

IPCC (2001) Climate change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (Houghton, J. T., Ding, Y., Griggs, D. J., Noguer, M., Van der Linden, P., Dai, X., Maskell, K. and Johnson, C. I. (Eds.)). Cambridge University Press, Cambridge and New York.

IPCC (2013): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate

Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

IPCC, 2012 - Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.)

James, R. and Washington, R. (2013). Changes in African temperature and precipitation associated with degrees of global warming. Climatic Change, 117(4): 859 – 872.

Jennings, S. and Magrath, J. 2009. What happened to the seasons? Oxfam GB research report.

Joshi, M., Hawkins, E., Sutton, R., Lowe, J. and Frame, D. (2011). Projections of when temperature change will exceed 2°C above pre-industrial levels. Nature Climate Change, 1(8): 407 – 412.

Juana J, Kahaka Z, Okurut F. Farmers' perceptions and adaptations to climate change in sub-Sahara Africa: a synthesis of empirical studies and implications for public policy in African agriculture. J Agric Sci. 2013; 5:121–135.

Kahn, M.E., 2003. Two measures of progress in adapting to climate change. Global Environmental Change, 13: 307–312.

Kemausuor F, Dwamena E, Bart-Plange A, Kyei-Baffour N. Farmers' perception of climate change in the Ejura-Sekyedumase district of Ghana. ARPN Journal of Agricultural and Biological Science. 2011; 6:25–37.

Kihupi M. L., Chingonikaya, E. E. and Mahonge, C. 2015. Smallholder Farmers' Perception of Climate Change Versus Meteorological Data in Semi-arid Areas of Iringa District, Tanzania. Journal of Environment and Earth Science www.iiste.org.ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online). Vol.5, No.2, 137

KombaC and Muchapondwa E. 2012. Adaptation to climate change by smallholder farmers in Tanzania, Economic research Southern Africa, Tanzania.

Kruger, A.C. and Shongwe, S. 2004. Temperature trends in South Africa: 1960-2003, International Journal of Climatology, 24, pp. 1929-1945.

Kurukulasuriya, P and Mendelsohn, R. 2006. A Ricardian Analysis of the impact of Climate Change on African Cropland, African Journal of Agricultural and Resource Economics, vol. 2(1), March.

Kuruppu N, Liverman D (2011) Mental preparation for climate adaptation: the role of cognition and culture in enhancing adaptive capacity of water management in Kiribati. Glob Environ Change 21(2):657–669.

Lawrence, M., Goodwin, P., & Fildes, R. (2002). Influence of user participation on DSS use and decision accuracy. Omega, International Journal of Management Science, 30, 381-392.

LEDET, Provincial Government of Limpopo, "Limpopo Green Economy Plan: Including Provincial Climate Change Response," une 2013. https://www.environment.gov.za/sites/default/files/docs/limpopogreen_economy plan.pdf

Legesse B, Ayele Y, Bewket W. Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, West Hararghe, Ethiopia. Asian Journal of Empirical Research. 2013; 3:251–265.

Legesse, B. and Drake, L. 2005 Determinants of smallholder farmers' perceptions of risk in the Eastern Highlands of Ethiopia.Journal of risk research. Routledge Informa Ltd. UK.

Legesse, B., Ayele, Y. & Bewket, W. (2012) Smallholder farmer's perceptions and adaptation to climate variability and climate change in Doba District, West Hararghe, Ethiopia.Asian J. Empir. Res. 3(3), 251–265.

Lesnoff M, Corniaux C, Hiernaux P, Sensitivity analysis of the recovery dynamics of a cattle population following drought in the Sahel region Sensitivity analysis of the recovery dynamics of a cattle population following drought in the Sahel region. Ecol Model. 2012; 232:28–39. doi: 10.1016/j.ecolmodel.

Liwenga, E.T. (2008), “Adaptive livelihood strategies for coping with water scarcity in the drylands of central Tanzania”, Physics and Chemistry of the Earth, PartsA/B/C, Vol. 33 No. 8–13, pp. 775–779.

Lorenzoni, I. & Pidgeon, N. F. Public views on climate change: European and USA perspectives. Clim. Change 77, 73–95 (2006).

Lorenzoni, I., Nicolson-Cole, S. & Whitmarsh, L. Barriers perceived to engaging with climate change among the UK public and their policy implications. Glob. Environ. Change 17, 445–459 (2007).

Low, P. S. (2005). Climate Change and Africa.Cambridge University, New York, pp.161-283.

Maddison, D. 2006 The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Mahmood, S. M. S., Najneen, F., Hoque, K. S., Rahman, S. & Shamin, M. M. (2010) Climate change: A study on impact and people’s perception (A case study on Mongla Upazila, Bagerhat district, Bangladesh). Bangladesh Res. Publ. J. 4(2), 153–164

Maponya P and Mpandeli S (2012) Climate Change and Agricultural Production in South Africa: Impacts and Adaptation options. Journal of Agricultural Science, 4: 10.

Maponya P and Mpandeli S (2013).Coping with climate change variability in Limpopo province, South Africa. Peak Journal of Agricultural Science, 4: 54-64

Maxwell, S. (1996). Food security: a post-modern perspective. Food Policy 21: 155-170. http://dx.doi.org/10.1016/0306-9192(95)00074-7

McCarthy J, Canziani O, Leary N, Dokken D, White K (eds.) (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. New York, Cambridge University Press.

Mendelsohn, R. and A. Dinar. 1999. "Climate Change, Agriculture, and Developing Countries: Does Adaptation Matter? ", The World Bank Research Observer 14: 277-293.

Mertz, O., C. Mbow, A. Reenberg, and A. Diouf, 2009: Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. Environmental Management, 43(5), 804-816.

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009) Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. Environ. Manage. 43(5), 804- 816.

Milder, J.C., T. Majanen and S.J. Scherr. 2011. Performance and Potential of Conservation Agriculture for Climate Change Adaptation and Mitigation in SubSaharan Africa. Ecoagriculture Discussion Paper No. 6.

Milne S, Sheeran P, Orbell S (2000) Prediction and intervention in health related behavior: a meta analytic review of protection motivation theory. J Appl Soc Psychol 30(1):106–143

Mohamed, A.B. (2011). Climate change risks in Sahelian Africa. Regional Environmental Change, 11(Suppl. 1): 109 – 117.

Molemole Integrated Environmental Management Plan & Framework, 2008/09.

Molemole Local Municipality 2015/16 Integrated Development Plan(IDP) and Budget (2015). www.molemole.gov.za/docs/idp/Molemole%20IDP.doc

Molemole Local Municipality 2017-18 Integrated Development Plan IDP report, 2017.www.molemole.gov.za/docs/idp/Molemole%20IDP.doc

Mortimore, M.J. and Adams, W.M., 2001. Farmer adaptation, change and 'crisis' in the Sahel. Global Environmental Change, 11: 49–57.

Moyo, M., B. Mvumi, M. Kunzekweguta, K. Mazvimavi, P. Craufurd, and P. Dorward. 2012. Farmer perceptions on climate change and variability in semi-arid Zimbabwe in relation to climatology evidence. African Crop Science Journal 20(2): 317–335.

Mpandeli S and Maponya P (2013). The use of climate forecasts Information by farmers in Limpopo Province South Africa. Journal of Agricultural Science, 5: 2.

Mugalavai, E.M., Kipkorir, E.M., Raes, D. and Rao, M.S. 2008. Analysis of rainfall onset, cessation and length of growing season for Western Kenya.Agricultural and Forest Meteorology 148:1123–1135.

Mzezewa J, Misi T and Van Rensburg LD (2010) Character isation of rainfall for sustainable crop production at a semi-arid ecotope in the Limopopo Province (SA). Water SA 36 (1) 19-26

NASA (2011) http://data.giss.nasa.gov/gistemp. Accessed [12 may 2017]

NDA (National Department of Agriculture) (2012). Abstract of Agricultural Statistics 2011, Directorate, Agricultural Information, NDA, Pretoria.

NDA (National Department of Agriculture), 2001a. Agricultural Digest 2000/2001. NDA, Pretoria.

Ndambiri HK, Ritho CN, Mbogoh SG (2013). An evaluation of farmers' perceptions and adaptation to the effects of climate change in Kenya. Int. J. Food Agric. Econ. 1(1):75-96. Nhemachena C, Hassan R (2007). Micro level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper 00714 August 2007.

Newing, H. (2011). Conducting Research in Conservation.A Social Science Perspective. London: Routledge.

Ngaira, J. K. (2007). Impact of climate change on agriculture in Africa by 2030. Scientific Research and Essays 2(7): 238 – 243.

Mendelsohn R, Dinar A (1999). Climate Change, agriculture, and developing countries: Does adaptation matter? The World Bank Res. Observer, 14(20): 277-293.

Nhemachena, C. (2009). Agriculture and Future Climate Dynamics in Africa: Impacts and Adaptation Options. Pretoria: University of Pretoria.

Nhemachena, C. and Hassan, R. 2007 Micro-Level Analysis of Farmers' adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper No. 714. Environment and production Technology division.

Niang, I., Ruppel, O.C., Abdrabo, M.A., Essel, A., Lennard, C., Padgham, J. and Urquhart, P. (2014): Africa.

Nicholson, S.E., Nash, D.J., Chase, B.M., Grab, S.W., Shanahan, T.M., Verschuren, D., Asrat, A., ALezine,.-M. and Umer, M. (2013). Temperature variability over Africa during the last 2000 years. Holocene, 23(8): 1085 – 1094.

Nielsen, J.Ø and A. Reenberg, 2010: Cultural barriers to climate change adaptation: a case study from Northern Burkina Faso. Global Environmental Change,20(1), 142-152.

Nyong, A., Adesina, F., & Elasha, O. B. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. Mitigation and Adaptation Strategies in Global Change, 787-797. http://dx.doi.org/10.1007/s11027-007-9099-0

O'Brien, G. O'Keefe, P. Rose, J. and Wisner, B. 2006 Climate change and disaster management.Disasters, 2006 Vol. 30.64-80. Overseas Development institute.Blackwell Publishing Oxford UK.

Odendo, M., Ojiem, J., Bationo, A., & Mudeheri, M. (2006).On-farm evaluation and scaling-up of soil fertility management technologies in western Kenya. Nutrient Cycling in Agroecosystems, 76, 369-381. http://dx.doi.org/10.1007/s10705-006-9060-8

Ofuoku, A. U. (2011). Rural Farmers' Perception of Climate Change in Central Agricultural Zone of Delta State, Nigeria. Indonesian Journal of Agricultural Science, 12(2), 63-69.

Ogalleh, S.A., C.R. Vogl, J. Eitzinger, and M. Hauser. 2012. Local Perceptions and Responses to Climate Change and Variability: The Case of Laikipia District, Kenya. Sustainability 4(12): 3302.

Orindi, V. A. and Murray, L. A. (Eds.) (2005). Adaptation to Climate Change in East Africa: A Strategic Approach. Gatekeeper Series No. 117.National Academic Press, Washington DC, USA. 12pp.

Orindi, V. A. and Murray, L. A. (Eds.) (2005). Adaptation to Climate Change in East Africa: A Strategic Approach. Gatekeeper Series No. 117.National Academic Press, Washington DC, USA. 12pp.

Osbahr H, Twyman C, Adger W and Thomas D (2010). Evaluating successful livelihood adaptation to climate variability and change in southern Africa. Ecology Society.15: 27.

Osbahr, H., C. Twyman, W. N. Adger, and D. S. G. Thomas. 2008. Effective livelihood adaptation to climate change disturbance: scale dimensions of practice in Mozambique. Geoforum 39:1951-1964

Osbahr, H., Dorward, P., Stern, R. and Cooper, S. 2011. Supporting agricultural innovation in Uganda to climate risk: linking climate change and variability with farmer perceptions. Experimental Agriculture 47 (2): 293-316.

Paavola, J., 2008: Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. Environmental Science and Policy, 11(7), 642-654.

Parry, M. L., Canziani, O. F., Palutikof, J. P., Van der Linden, P. J. and Hanson, C. E. (Eds.) (2007). Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. 976pp.

Patt A, Schröter D. Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. Glob Environ Chang. 2008; 18:458–467. doi: 10.1016/j.gloenvcha.2008.04.002.

Phuong, L. T H. (2011). Climate change and farmers' adaptation A case study of mixed - farming systems in the coastal area in Trieu Van commune, Trieu Phong district, Quang Tri province, Vietnam, Master's Thesis, Hue University of Agriculture and Forestry, Vietnam.

Rakgase M, Norris D. (2014). Factors that Influence Choice of Drought Coping Strategies in Limpopo Province, South Africa. Journal of Human Ecology, 47(2): 111–116.

Rawat, M. (2010). People's perception on the impact of climate change in Garhwal Himalaya region: A case study from Kunjapuri Hills. Reflections of Climate Change Leaders from the Himalayas, Leadership for Environment and Development (LEAD) report, India, New Delhi.

Rdsu (2003): "Qualitative research methods", [Online] Peninsula, Peninsula Research and Developmentsupport Unit (RDSU). Available from: http://projects.exeter.ac.uk/prdsu/helpsheets/Helpsheet09-May03-Unlocked.pdf [Accessed 15 September 2016].

Recha, C.W., Shisanya, C. A., Makokha, G. L. and Kinuthia, R.N. 2008. Perception and Use of Climate Forecast Information Amongst Smallholder Farmers in Semi-Arid Kenya. Asian Journal of Applied Sciences 1 (2):123135.

Ribot, J.C., Magalhães, A.R. and Panagides, S.S. (Eds.), 1996.Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics.Cambridge University Press, Cambridge, UK.

Roncoli, C., Ingram, K., Kirshen, P., 2002. Reading the rains: local knowledge and rainfall forecasting in Burkina Faso. Society & Natural Resources 15, 409–427.

Salick, J. & Byg, A. (2009) Local perspectives on a global phenomenon – climate change in Eastern Tibetan villages.Glob. Environ. Chang. 19, 156–166.

SANBI (South African National Biodiversity Institute). 2009. National Land Cover Map. Pretoria: SANBI.

Sánchez-Cortés, M. S., and E. L. Chavero. 2011. Indigenous perception of changes in climate variability and its relationship with agriculture in a Zoque community of Chiapas, Mexico. Climatic Change 107:363-389. http://dx.doi.org/10.1007/s10584-010-9972-9

Sanderson, M.G., Hemming, D.L. and Betts, R.A. (2011). Regional temperature and precipitation changes under warming. Philosophical Transactions of the Royal Society A, 369(1934): 85 – 98.

Scoones, I. 2004. Climate change and the challenge of non-equilibrium thinking. IDS Bulletin 35: 114-119.

Seo, S.N., Mendelsohn, R., Munasinghe, M., 2005.Climate change and agriculture in Sri Lanka. Environment and Development Economics, 10: 581–596.

Sheil, D., and A. Lawrence. 2004. Tropical biologists, local people and conservation: new opportunities for collaboration. Trends in Ecology and Evolution 19:634-638. http://dx.doi. org/10.1016/j.tree.2004.09.019

Sherlund, S.M., Barrett, C.B., Adesina, A.A., 2002. Smallholder technical efficiency controlling for environmental production conditions. Journal of Development Economics, 69(1): 85–101.

Shiferawa B, Tesfaye K, Kassie M, Abate T, Prasanna B, Menkir A. (2014). Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa:

Technological, institutional and policy options. Weather and Climate Extremes, 3:67–79.

Simelton E, Quinn CH, Batisani N, Dougill AJ, Dyer JC, Fraser EDG, Mkwambisi D, Sallu S, Stringer LC (2013) Is rainfall really changing? Farmers' perceptions, meteorological data, and policy implications. Clim Dev 5:123–138

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

Smit, B. and Pilifosova, O., 2001. Adaptation to climate change in the context of sustainable development and equity. In J.J., McCarthy, O.F., Canziani, N.A., Leary, D.J., Dokken and K.S., White (Eds.), Climate Change 2001: Impacts, Adaptation and Vulnerability (pp. 877–912). Cambridge University Press, Cambridge, UK.

Smit, B., and Pilifosova, O. (2001). Adaptation to Climate Change in the context of sustainable development and Equity.' In: Climate Change 2001 Impacts, Adaptation, and Vulnerability contribution of Working Group II to the Third Assessment Report of the IPCC. (Edited by McCarthy J.J., Canziani, O. F., Leary, N. A., Dokken, D. J., White, K. S.) Cambridge University Press, Cambridge.877 – 912.

Smit, B., Wandel, J. (2006) Adaptation, Adaptive Capacity and Vulnerability, Global Environmental Change, 16, 282–92.

Smithers, J., & Smit, B. (2009). Human Adaptation to Climatic Variability and Change. In L. E. Schipper & I. Burton (Eds.), Adaptation to Climate Change (pp. 15-33). London: Earthscan.

Stats SA. 2013. Census of Commercial Agriculture 2013 (Preliminary). Pretoria: StatsSA (Statistics South Africa), Census information, 2011. http://www.statssa.gov.za/?page_id=993&id=molemole-municipality

Stern, D.I., Gething, P.WKabaria, C.W., Temperley, W.H., Noor, A.M., Okiro, E.A., Shanks, G.D., Snow, R.W. and Hay, S.I. (2011).Temperature and malaria trends in highland East Africa. PLoS ONE, 6(9): e24524, doi: 10.1371/journal.pone.0024524.

Tadross, M., 2006.Climate change scenarios for the Olifants catchment area. In South Africa Pilot Study Report: Climate Change and Water Resource Planning in Polokurane, Smith, J.B. (Ed.) Report for USAID, stratus consulting Inc., Boulder, CO, USA. p. 139.

Teddlie, C., & Yu, F. (2007). Mixed methods sampling: A typology with examples. Journal of Mixed Methods Research, 1, 77-100.

Tenge De Graaff, J. & Hella, J.P. (2004). Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands, Tanzania. Land Degradation and Development 15 (2), 99–114.

Tshiala M, Olwoch J. (2010). Impact of climate variability on tomato production in Limpopo Province, South Africa. African Journal of Agricultural Research, 5(21):2945–2951.

Tucker, C. M., Eakin, H. & Castellanos, E. J. (2010) Perceptions of risk and adaptation: coffee producers, market shocks, and extreme weather in Central America and Mexico. Glob. Environ. Chang. 20, 23–32.

Tweeten L.G. 1997. Promoting Third-World Development and Food Security.Luther G. Tweeten and Donald G. McClelland.Wesport.

UNICEF, “Exploring the Impact of Climate Change on Children in South Africa,” 2011. http://www.unicef.org/southafrica/SAF_resources_climatechange.pdf

van Duinen, Filatova T, van der Veen A. (2011). Understanding farmers’ drought risk adaptation in the Netherlands.IGS-SENSE CONFERENCE Paper; www.utwente.nl/...resilientsocieties/Papers%20and%20presentations%20..Accessed 10 September 2015.

Villamor, G. B., Palomo, I., Santiago, C. A. L., Oteros-rozas, E. & Hill, J. (2014) Assessing stakeholders' perceptions and values towards social-ecological systems using participatory methods. Ecol. Process. 3(22), 1–12. doi:10.1186/s13717-014-0022-9

Weber, E. U. (2010). What shapes perceptions of climate change? Wiley Interdisciplinary Reviews: Climate Change 1 (3), 332-342. doi:10.1002/wcc.41, http://dx.doi.org/10.1002/wcc.41

Wehbe, M., Eakin, H., Seiler R., Vinocour, M., Avila, C. and Marutto C. 2006 Local perspectives on adaptation to Climate change: Lessons from Mexico and Argentina. AIACC working paper no. 39. USA.

West, C.T., Roncoli, C., & Ouattara, F. (2008) Local perceptions and regional climate trends on the Central Plateau of Burkina Faso. Land Degradation & Development. 19(3), 289-304

WMO. (2007) The role of climatological normals in a changing climate. WCDMP-No. 61. WMO-TD No. 1377. Organization 130.

Woodward FI (1987). Climate and Plant Distribution. Cambridge University Press, New York.

World Resources Institute, 1996 World Resources: A Guide to Global Environment, 1996-1997. World Resources Institute, United Nations Environment Program, World Bank, Oxford University Press.

Ziervogel, G., S. Bharwani, and T.E. Downing. 2006. Adapting to Climate Variability: Pumpkins, People and Policy. Natural Resources Forum 30(4): 294-305.

Appendix 1: Semi-structured questionnaire

Questionnaire #: ________ Village: ____________ Date: _______________

Farmer Code Name: ____

Part 1: Farmers Demographic Information (Mark a cross (X) on the appropriate answer)

	Description				
Age	< 30	30 – 40	41 – 50	51 – 60	> 60
Gender	Male		Female		
Level of education	No education	Primary	Secondary		Other…
Farming experience (years)	5 – 10	11 – 20	21 – 30		> 30
Farm size (Hectare)	0 – 1	2 – 3	3 – 4		> 4
Access to information on climate variability	Yes		No		
If yes, through:	Media	Agricultural extension officers		Indigenous Knowledge	

Part 2: Farmers perception on climate variability (Select the appropriate answer)

	Agree	Disagree	No change	Not sure
1. Rainfall has increased				
2. Rains start earlier than expected				
3. Wet season ends earlier				
4. There is increase in dry spells				
5. Number of rainy days are fewer				
6. Temperature has increased				
7. Winter is warmer				
8. Summer is hotter				
9 Winter is shorter				
10. Summer lasts longer				

Scoring: Agree = 1, Disagree = 2, No change = 3, Not sure = 4

Part 3: Farmers adaptation strategies to climate variability

	Adaptive strategy	Level of Importance			
		High	Medium	Low	No
Crop management	Crop diversification				
	Use different planting dates				
	Plant different varieties				
	Shorter growing periods				
Soil fertility management	Soil conservation, mulching and manure				
	Change use of fertilizers and pesticides				
Socio-economic strategy	Move to different site (or village)				
	Change land size				
	Change from crops to livestock				
	Change from farming to non-farming				
	Use insurance				
	Use subsidies				
Water management	Increase irrigation system				
	Change water conservation practice				
*Use of Indigenous Knowledge	If yes, specify…				

Appendix 2: Interview Guide

1. Have you observed any variations (changes) in climate in your area?
2. In what ways has the climate change?
   Temperature increase, rainfall patterns etc...
3. Over which periods (referring to the past 5 to 10 years) have you observed these changes?
4. How have these changes affected you?
5. What adaptation measures have you implemented and why?

Appendix 3: Semi-structured questionnaire (Sepedi)

Lenaneopotšišo #: ________ Motse:__________Letšatšikgwedi: ________________

Leina la molemi la boitsebišo: ____

Karolo ya 1: Tshedimošo ya dipalopalo tša molemi (Swaya ka (X) moo karabo ye e swanetšego)

	Tlhalošo				
Ke na le nywaga e	< 30	30 – 40	41 – 50	51 – 60	> 60
Bong	Tona		Tshadi		
O fihlie kae ka tša thuto	Ga ka tsena sekolo	Sekolo sa phoraemari	Sekolo sa sekontari		Tše dingwe
Maitemogelo go tša temo (mengwaga)	5 – 10	11 – 20	21 – 30		> 30
Bogolo bja Tšhemo (Hectare)	0 – 1	2-3	3-4		> 4
Tumelelo ya tshedimošo ya tša phetogo ya tša boso	Ee		Aowa		
Ge karabo e le Ee, e tla ka tsela ya:	Diphatlalatšo	Bahlankedi ba katološo go tša temo		Tsebo go tša tlhago	

Karolo ya 2: Temogo ya balemi, mo phetogong ya tša boemo bja boso (Kgetha karabo ya maleba)

	Ee	Aowa	Ga go na phetogo	Ga ke na bonnete
1. Dipula di oketšegile				
2. Dipula di na pele ga nako				
3. Sehla sa dipula se fela ka pela				
4. Go na le koketšo ya komelelo				
5. Palo ya matšatši ao pula e nago, ga se a mantši				
6. Themphereitšhara e oketšegile				
7. Marega a ruthafetše				
8. Selemo se fiša kudu				
9. Nako ya marega ke e nyane				
10. Selemo se tšea nako e telele				

Go nweša: Ee = 1, Aowa = 2, Ga go na phetogo= 3, Ga ke na bonnete = 4

Karolo ya 3: Maano a tlwaetšo ga balemi mabapi le phetogo ya boemo bja boso

	Mekgwa ya tlwaetšo	Level of Importance			
		High	Medium	Low	No
Taolo ya dibjalo	Fapanego ya dibjalo				
	Tšhomišo ya matšatši ao a fapanego go bjala				
	Mehutahuta yeo e fapafapanego ya sebjalo				
	Lebaka le le kopana la kgolo ya dibjalo				
Taolo ya go nona ga mobu	Morole (Manure), tšhireletšo le pabalelo ya mobu				
	Phetogo ya tšhomišo ya merole, le sebolai sa dikhunkhwane				
Socio-economic strategy	Go tširogela lefelong le lefša (goba motseng wo mofša)				
	Phetogo ya bogolo bja naga				
	Phetogo go tšwa go djalo go iša go leruo				
	Phetogo go tšwa go lema go iša le go se leme				
	Tšomišo ya inšorense				
	Tšomišo ya thekgo ya ditšhelete				
Taolo ya meetse	Koketšo ya tsela ya go nošetša				
	Phetogo ya tlaetšo ya go babalela meetse				
* Tšomišo ya tsebo go tša tlhago	Ge karabo ya gago e le ee, tlhaloša…				

Appendix 4: Focus Group Discussion (Sepedi)

Tlhahlo ya poledišano

1. O lemogile phetogo ya boemo bja boso tikologong ya geno?
2. Ke ka mekgwa e fe yeo boemo bja boso bo fetogilego ka gona?
   Mohl. Koketšo ya thempereitšhara, mosego wa dipula bj.bj..
3. Ke ka dinako / sebaka (re lebeletše nywaga yeo e ka ba go ye mehlano go iša go ye lesome yeo e fetilego) di fe /se fe moo o lemogilego diphetogo tše?
4. Diphetogo tše di go amme bjang?
5. Ke kgato di fe tša tlwaetšo tšeo o di diragaditšego, le gona ke ka lebaka la eng?

Appendix 5: Consent Form

Project title: **<u>Smallholder farmers' perceptions on climate variability in relation to climatological evidence in the Molemole Municipality (Limpopo Province) South Africa</u>**

Project leader: **Rapholo Maropene Tebello Dinah (201405403)**

I, hereby voluntarily consent to participate in the following project: "Smallholder farmers' perceptions on climate variability in relation to climatological evidence in the Molemole Municipality (Limpopo Province) South Africa."

I understand that:

1. My responses will be treated with confidentiality and only be used for the purpose of the research.
2. No harm will be posed to me.
3. The research project aim has been explained to me.
4. I do not have to respond to any question that I do not wish to answer for any reason.
5. Access to the records that pertain to my participation in the study will be restricted to persons directly involved in the research.
6. Any questions that I may have regarding the research, or related matters, will be answered by the researcher.
7. Participation in this research is entirely voluntary and I can withdraw my participation at any stage.

Signature of interviewee **Signature of interviewer**

______________________ ______________________

Signed at________________________on this_____day of____________20__

Appendix 6: Faculty approval letter

Faculty of Science and Agriculture

08/03/2017

NAME OF STUDENT:	RAPHOLO M.D.T.
STUDENT NUMBER:	201405403
DEPARTMENT:	Geography and Environmental Studies
SCHOOL:	Agriculture and Environmental Sciences
QUALIFICATION:	SGEA090

Dear Ms Rapholo MDT (201405403)

FACULTY APPROVAL OF PROPOSAL (PROPOSAL NO.49 OF 2016)

I have pleasure in informing you that your masters proposal served at the Faculty Higher Degrees Committee meeting on **13th October 2015** and your title was approved as follows:

"Smallholder farmer's perceptions on climate variability in relation to climatological evidence in the Molemole Municipality (Limpopo Province) South Africa."

Note the following: The study

Ethical Clearance	Tick One
Requires no ethical clearance Proceed with the study	
Requires ethical clearance (Human) (TREC) (apply online) Proceed with the study only after receipt of ethical clearance certificate	√
Requires ethical clearance (Animal) (AREC) Proceed with the study only after receipt of ethical clearance certificate	

Yours faithfully

Prof P Masoko
Secretariat: Faculty Higher Degrees Committee

CC: Dr. G. Tawodzera
Prof TP Mafeo

Appendix 7: Request to conduct research

PO BOX 279

Dwars River

0812

22 June 2016

Molemole Local Municipality

Satellite Office

PO Box 48

Morebeng

0810

REQUEST TO CONDUCT RESEARCH IN BOTLOKWA VILLAGE

Dear sir/madam

My name is Maropene Tebello Dinah Rapholo, a Masters full time student at the University of Limpopo in the Geography and Environmental Studies Department. I would like to request to conduct a study and would like smallholder (subsistence) farmers in Botlokwa Village to participate in focus group discussions and to participate in a survey. A copy of my research proposal (including topic) and proof of registration are being attached for verification and clarity.

Regards

Ms MTD Rapholo
Cell number: 0604635728
Email Address: ramusimaropene@gmail.com

Appendix 8: Approval Letter

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
CO-OPERATIVE COVERNANCE,
HUMAN SETTLEMENTS & TRADITIONAL AFFAIRS

Date: 27/06/2016
To: Ms MTD RAPHOLO (UNIVERSITY OF LIMPOPO)
Nature of the case: REQUEST TO CONDUCT RESEARCH

It is with great pleasure to inform you **Ms MTD RApholo from the University of Limpopo** that your request to conduct research on **" SMALLHOLDER FARMERS' PERCEPTIONS ON CLIMATE VARIABILITY IN RELATION TO CLIMATOLOGICAL EVIDENCE IN THE MOLEMOLE MUNICIPALITY (LIMPOPO PROVINCE) SOUTH AFRICA** has been approved.

The following conditions should be adhered to:

1. The research should not have any financial implications for Molemole Municipality or Botlokwa Village.

2. Arrangements should be done with the Machaka-Makgatho- Ramokgopa Tribal Office concerned heads.

During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation.

Municipal Stamp/Traditional Affairs Stamp

Signed: [signature]

Contact: 083 793 1165

Name of official: Ms G. MAKGOBATLOU

MOLEMOLE MUNICIPALITY
2016 -06- 2 7
SATELLITE OFFICE
PO BOX 48, MOREBENG, 0810

Appendix 9: Ethical clearance certificate

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	4 July 2017
PROJECT NUMBER:	TREC/189/2017:PG
PROJECT:	
Title:	Smallholder farmers' perceptions on climate variability in relation to climatological evidence in the Molemole Municipality (Limpopo Province) South Africa
Researchers:	Ms MTD Rapholo
Supervisor:	Dr G Tawodzera
Co-Supervisor:	Dr ML Diko
School:	Agriculture and Environmental Science
Degree:	Masters in Geography and Environmental Studies

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**

ii) **The budget for the research will be considered separately from the protocol.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

Finding solutions for Africa