PERCEPTION AND ADAPTATION STRATEGIES OF SMALLHOLDER FARMERS TO DROUGHT IN THE FREE STATE PROVINCE, SOUTH AFRICA

BY DAKALO MUTHELO

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Supervisor: Dr A.A. Ogundeji

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Department of Agricultural Economics

University ofthe Free State

DECLARATION

I, Dakalo Muthelo, hereby declare that this dissertation submitted for the degree of Master of Science in Agricultural Economics in the Faculty of Natural and Agricultural Sciences, Department of Agricultural Economics at the University of the Free State is my own independent work, and has not been previously submitted by me to any other university. I am aware that the copyright of the thesis is vested in the University of the Free State.

Dakalo Muthelo | Date

Bloemfontein

July 2018

DEDICATION

I dedicate this work to my parents (Alex and Khakhu Muthelo), who sacrificed so much for me and gave me unending support and encouragement throughout. God bless you.

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ABSTRACT

Drought is defined as an insufficiency of rainfall over an extended period of time. Drought has affected a large number of smallholder farmers in the Free State province, and more importantly, in Thaba 'Nchu. The causes of vulnerability to drought risk in the Free State province are low average rainfall, poverty and inequitable development in rural areas. During drought periods, smallholder farmers cannot manage or cope with drought without external influence in terms of assistance or relief packages from government and non-governmental agencies. It is widely believed that the response of government to relief packages in times of hazards and natural disasters us usually either late, inadequate or non-existent, which makes farmers more vulnerable to drought. An assessment of smallholder farmers' perceptions of drought can help uncovering the nature of the risk and the underlying factors associated with socio-economic consequences. It is important to gain the perceptions of smallholder farmers, because any attempts to elicit adaptive behavioural patterns should come only after understanding how climate variability is perceived by farmers and what shapes their perception.

The main objective of this research was to understand smallholder farmers' perceptions ofand coping strategies with regard to drought in Thaba 'Nchu in the Free State Province of South Africa. In order to cope with the effects of drought, different coping strategies were adopted by smallholder farmers in Thaba 'Nchu, based on the limited resources available at the household level as well as external help. The study analysed the factors that influence which coping/adaptation strategies farmers choose during drought in the Free State province.Data for this study was collected using structured questionnaires. A sample size of 301 smallholder farmers from Thaba 'Nchu was used. Thesustainable livelihoods framework (SLF) was used to identify and describe the different capitals that were used to analyse the social conditions of the farmers and was used to indicating vulnerability. The development and use of indicators to analyse social conditions show how vulnerable smallholder farmers are to drought when looking at the different demographics. The multinomial logit model (MLM) was used to examine the factors that influence farmers' choice of coping/adaptation strategies in the study area.

The study revealed that farmers in Thaba 'Nchu are aware of the frequency of drought and that it is going to occur in the years to come. The farmers perceived vegetation loss as a very severe effect of drought. The inability to cope with and recover from drought makes farmers more vulnerable. The most frequently used coping strategies by smallholder farmers in Thaba 'Nchu during the 2015/2016 drought were rainwater harvesting and assistance from the government. Although most of the farmers did not have access to extension services, they made use of the available resources to help them cope. Different adaptation measures were used during the 2015/2016 drought in Thaba 'Nchu and the majority of the farmers implemented water-use restriction as a coping strategy. The analysis showed that characteristics such as age, gender, drought frequency, education, monthly income and farming skills were the most important contributors to the farmers' choice of coping strategies. The results show that factors such as gender, age, farming skills, drought frequency and the natural capital index positively influence farmers' choices of effective adaptation strategies. Improving insurance scheme is negatively influenced by seasonal farming. Primary, secondary and tertiary education, monthly income and the economic capital index positively and negatively influence choices of effective adaptation strategies. Technical measures are positively influenced by the human capital index. Improving forecasting is negatively influenced by institutional capital index. Smallholder farmers used different coping strategies, based on their available resources. The main conclusion from this study is that smallholder farmers in Thaba 'Nchu are affected by drought and have the potential to prepare and apply certain coping strategies when drought occurs in the future. This can be achieved with help from the Department of Agriculture and policymakers implementing new policies that aid adaptation. This study provides solutions for smallholder farmers on how to cope better with drought in the coming years.

Key words: Drought, vulnerability, smallholder farmers, perception, coping strategies, Free State province, Thaba 'Nchu

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LIST OF ABBREVIATIONS AND ACRONYMS

BFAP	Bureau for Food and Agricultural Policy
CIMMYT	International Maize and Wheat Improvement Center
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DFID	Department for International Development
GDP	Gross domestic product
IFAD	International Fund for Agricultural Development
MMM	Mangaung Metropolitan Municipality
MNL	Multinomial logit
NGO	Non-governmental organisations
NMSA	National Meteorological Services Agency
NOAA	National Oceanic and Atmospheric Administration
RED	Regionally extensive droughts
SADC	Southern African Development Community
SAWS	South African Weather Services
SLA	Sustainable livelihood framework
SSA	Sub-Saharan Africa
WRC	Water Research Commission
ZENID	The Queen Zein Al Sharaf Institute for Development

CHAPTER 1: INTRODUCTION

1.1 Background and Motivation

Drought is one of the most disastrous climate-related threats in the world, with effects on agriculture, the environment, infrastructure, and socioeconomic activities (Moeletsi and Walker 2016). Drought is defined as an insufficiency of rainfall over an extended period of time, usually a period of a month or more, resulting in a shortage of water and giving rise to adverse effects on vegetation, animals and people (Msangi 2004; National Oceanic and Atmospheric Administrations (NOAA) 2006; Rouault and Richard 2003). Droughts are an endemic feature of the African landscape (Boko et al., 2007).

Agriculture is a major social and economic sector in the Southern African Development Community (SADC) region, contributing between 4% and 27% of the region's gross domestic product (GDP). The majority of the population in the region depends largely on agriculture for its primary source of life, employment and income (Department of Environmental Affairs 2014). Smallholder farming is the most widely used method of agricultural farming in Sub-Saharan Africa, with the majority of the rural poor depending on it for survival (Department of Agriculture, Forestry and Fisheries 2010). However, South Africa has a more productive and competitive agricultural sector compared with other countries in the region (Department of Agriculture Forestry and Fisheries 2010).

Drought is a recurrent phenomenon, occurring at different concentrations in South Africa (Backeberg and Viljoen 2003). The year 2015 was officially declared the driest year in South Africa since 1904 (South Africa Weather Service 2015). Resource-poor farmers whose productivity is highly threatened by frequent droughtswere affected the most. These droughts are due to the high inconsistency of inter-annual and intra-seasonal rainfall over most parts of South Africa (Rouault and Richard 2003; Tyson and Preston-Whyte 2000). In semiarid regions like the Free State province of South Africa, drought is the climate hazard that has the most harmful effect on farmers (Wilhelmi 1999). The risks posed by drought are dependent on the interaction of drought with the vulnerability of both human and natural systems, as well as their ability to adapt (Field et al. 2014).

The causes of vulnerability to drought risk in the Free State province are: below average rainfall, poverty and inequitable development in rural areas, rapid population growth and urbanisation, inequitable land distribution, lack of education, and subsistence agriculture on marginal land – leading to deforestation and environmental degradation, malnutrition and unemployment (Olaleye 2010). Adjustments within social factors, such as community size, community characteristics, social behaviour, policy and coping mechanisms, influence vulnerability (Wilhite 2000). Therefore, social factors in a community can either increase or decrease farmers' vulnerability to drought. In South Africa, the severity of droughts has different effects on the community at large, specifically when focusing on their livelihood (Shoroma 2014).

Communal and resource-poor farmers in the rural areas of the Free State are often overwhelmed by interrelated and complex problems that they have to deal with on a daily basis and by adaptation mechanisms in order to survive on a daily basis (Below et al. 2010). Adaptation helps farmers achieve food security, income and livelihood objectives in the face of climate variability and changing socio-economic conditions, such as volatile short-term changes in local and large-scale markets (Boko et al. 2007; Gwimbi 2009). Adaptation to climate variability involves the identification of mechanisms that farmers can implement within their circumstances to offset the unpredictable nature of the climate. Individual perception of the risks associated with climate variability is fundamental in determining the farmers' ability to adapt, as perception usually translates into the agricultural decision-making process (Bryant et al. 2000).

1.2 Problem Statement

Coping and adaptation choices are limited by insufficient knowledge and the low levels of resources or livelihood assets available to farmers during vulnerable situations, such as drought and other climate hazards. Also, reducing vulnerability is a key feature of improving smallholder farmers' adaptive capacity and resilience to drought. However, the extent to which farmers' level of vulnerability influences their choice of coping or adaptation strategies remains uncertain. Studies focus on the socio-economic aspects of global climatic variability, almost exclusively restricting their analyses to the impact of environment on agricultural production (Legesse and Drake 2005).

During drought periods and beyond, the smallholder farmers are often left without their livelihood and investment in agriculture. During drought periods, smallholder farmers cannot manage or cope with drought without external assistance in terms of relief packages from governmental and non-governmental agencies (South African Government Gazette 2005). Drought can lead to food shortages and social unrest, and stall land distribution. In many areas, drought has forced farmers to sell off some of their livestock to buy fodder for the rest (Mudombi 2011).

According to Monnik (2000), farmers are more vulnerable to drought because it is widely believed that government's response to providing relief packages in times of hazards and natural disasters is usually inadequate, late or non-existent. Previous studies suggest that drought can affect different areas and people within the same area differently (Olaleye 2010), and the subsequent effects felt by households or individuals and their coping strategies or mechanisms could be influenced greatly by their previous status in terms of their access to various capital or assets, such as wealth, information, financial aid and loans (Olaleye 2010). The problem is that vulnerability is not accounted for, andsmallholder farmers are the ones who are most affected and vulnerable during the occurrence of drought, since they depend on agriculture for their livelihood. There are serious consequences of drought on agriculture and food security and, consequently, the livelihood of rain-fed agriculture-dependent farming communities (Alam 2015). According to Apata, Samuel, and Adeola (2009), perception and adaptation studies help in better understanding the communities' perceptions of climate change and their existing adaptation strategies.

An important part of the solution is to put people who are vulnerable at the centre of communication for adaptation. This requires treating the end users of information not merely as a target audience, but as partners in co-learning through processes and products that reflect their own contributions (Roncoli, Ingram, and Kirshen 2001). There are number of success stories about adaptation among the most vulnerable, but they are mostly from the more developed countries and have been developed from projects (Grothmann and Patt 2005). The imperative is now to accelerate the process of replication and dissemination of best practices. Adaptation and coping strategies to drought need to spread out, and this requires innovative approaches to knowledge sharing.

1.3 The Objectives of the Study

The main objective of this study was to understand smallholder farmers' perceptions ofand coping strategies with drought in Thaba 'Nchu in the Free State province of South Africa.

The main objective of the study was achieved by pursuing the following sub-objectives:

1. To determine farmers' perceptions of drought.

2. To determine smallholder farmer's levels of vulnerability to drought using their access to capital or assets during drought.
3. To identify the current adaptation and coping strategies used by smallholder farmers in Thaba 'Nchu.
4. To determine factors influencing their choice of adaptation strategies in order to know the extent of farmers' levels of vulnerability and how these can affect the choice of coping or adaptation strategies during drought.

1.4 The organisation of the study

The study is structured into five main chapters. The relevant literature related to the research is discussed in Chapter two, in which drought and its types, farmers' vulnerability to drought, farmers' perceptions of drought vulnerability to drought impacts, coping and adaptation to drought and the empirical literature on factors influencing smallholder farmers' choice of adaptation strategies are discussed. *Chapter three* comprises a discussion of the study area, sources of data, sampling procedure and socio-economic characteristics of the respondents, and explains the procedures used to address the stated research objectives. *Chapter four*gives a presentation and discussion of the results obtained. The dissertation is concluded in *Chapter five*, which outlines the summary, conclusion and policy recommendations of the study.

CHAPTER 2: LITERATURE REVIEW

This chapter consists of five main sections. The first section discusses drought, providing a review of the literature on different types of droughts, the impacts of drought, farmers' vulnerability to drought impacts, and the impact of drought in South Africa and the Free State province. The second section comprises of farmers' perceptions of drought. The third section reviews vulnerability to drought impacts, with an explanation of the livelihood framework of assessment of farmers' vulnerability. The fourth section reviews the different coping and adaptation strategies to drought in South Africa and other countries. The final section reviews the empirical literature on factors influencing smallholder farmers' choices of certain adaptation strategies among others. Lastly, the methods for estimating the factors that influence the choice of adaptation strategies are discussed.

2.1 Drought

2.1.1 Definition and types of droughts

Drought can be described in different ways and in different forms, such as types of droughts, characteristics of droughts and vulnerability to drought. They are also describedin terms of the specific region and the impact at the time. There are two types of definitions of droughts: (1) conceptual and (2) operational. Conceptual definitions help understand the meaning of drought and its effects, and operational definitions help to identify the drought's beginning, end and degree of severity (National Drought Mitigation Centre 2006). Drought is defined as a manageable risk because it supports the identification of vulnerability and the improvement of drought resilience. In agriculture, this is accomplished by adopting a more holistic systems view of farming, leading to transformational changes such as shifts in management intensity, new or alternative production systems that are more appropriate for the climatic variability of a given region, andrestructuring business to adapt to the dual risk of price and climate variability (Oduniyi 2013).

Meteorologists generally define drought as a prolonged period of dry weather caused by a lack of precipitation that results in a serious water shortage for some activity, population or ecological system (Vogel 2005). According to Hazelton et al. (1994), drought is defined as a condition resulting in a reduction of the utilisable water resources in a region or specific area, to the extent that the community does not have sufficient or enough access to water resources. Shoroma (2014) defines drought as a shortage of rainfall from expected or normal rainfall that, over a season or longer period, is insufficient to meet the demands of human activities, resulting in economic, social and environmental impacts. There are many reasons and definitions for droughts. According to Bang and Sitango (2003), one can differentiate between four types of droughts. These are meteorological, hydrological, socio-economic and agricultural droughts. Identifying the type of drought can help one measure its severity.

Meteorological drought is expressed on the basis ofthe degree of dryness and the duration of the dry period due to a deficiency in precipitation. It is expressed in relation to the average conditions of the region over a long period. It is usually an indicator of potential water crisis if the condition is prolonged. Meteorological drought can begin and end immediately (Wilhite 2000).

Hydrological drought is associated with the effects of periods of rainfall shortages on surface or sub-surface water supply and water storage systems. Hydrological drought does not usually occur at the same time as meteorological and agricultural droughts. The decline in the quantity and quality of surface and sub-surface water is in a way the effect of meteorological drought (Wilhite 2000).

Agricultural drought usually occurs when the level of soil moisture is affected due to atmospheric moisture being reduced. When agricultural drought takes place, crops and animals, as well as evapotranspiration, are affected. These are often the signs one sees when a meteorological drought is at play, but not before a hydrological drought (Wilhite 2000).

Socio-economic drought is defined as a correlating supply and demand of goods and services, which means that the supply of certain goods and services, such as water and electricity that depend on the weather, may be affected and the drought may cause a shortage in the supply of these economic goods (Glantz et al. 1997).

These droughts are generally classified into four categories (American Meteorological Society 2006; Wilhite and Glantz 1985), which are presented in Figure 2.1.

2.1.1.1 Relationship between the various types of drought and duration of drought events

Figure 2.1 explains the relationship between the various types of droughts and the duration of the drought event. Depending on the timing of the rainfall insufficiency, drought usually takes three or even more months to develop, although the time differs considerably. For example, a significant dry period during the winter season may have few, if any, impacts in many places. Nonetheless, if this deficiency continues into the growing season, the impacts may magnify quickly, since low precipitation during the autumn and winter seasons results in low soil moisture recharge rates, leading to deficient soil moisture at spring planting (Wilhite 2000).

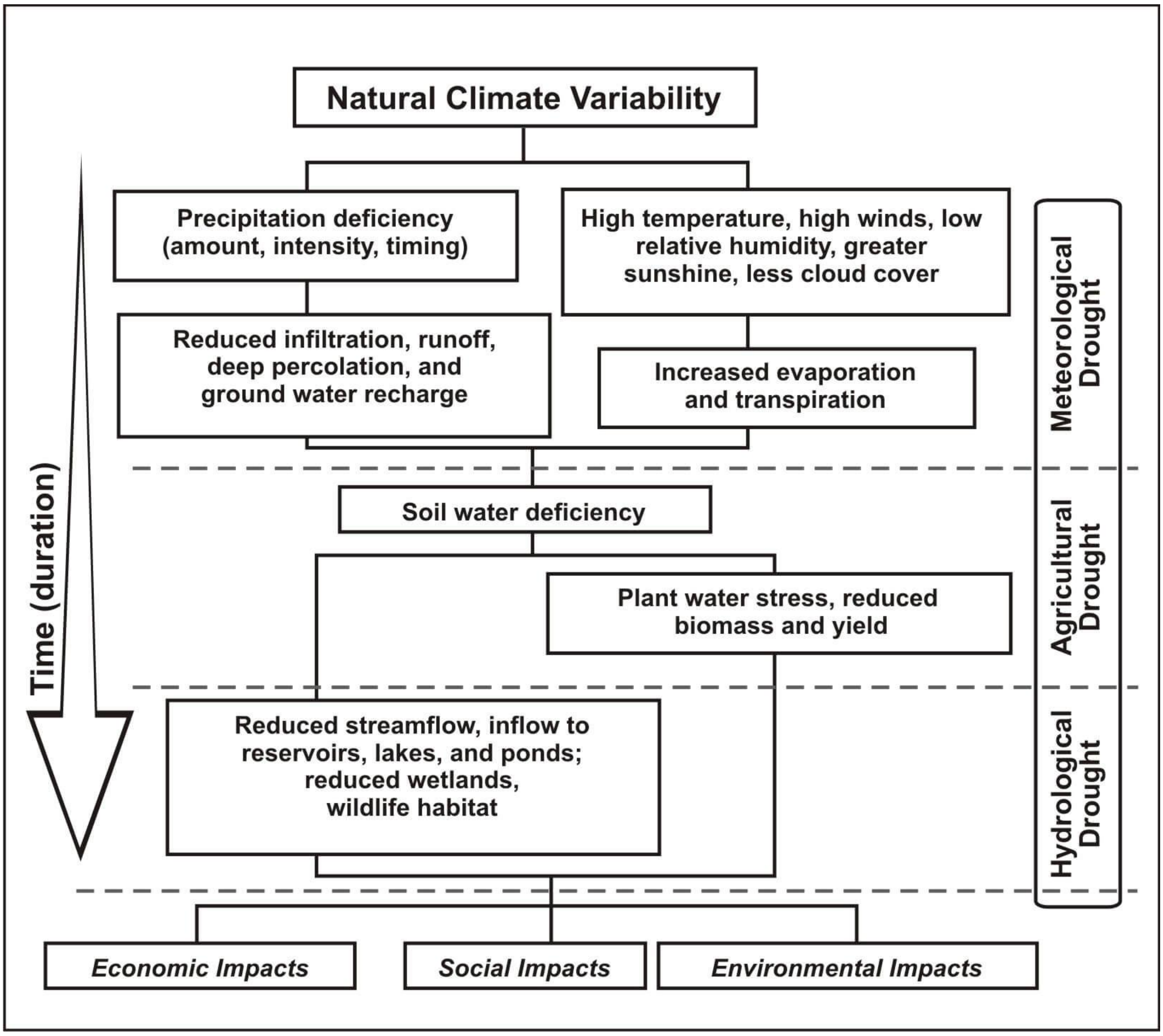

Figure 2.1. The relationship between various types of droughts and duration of drought events.

Source: National Drought Mitigation Center (2014).

2.1.2 Impacts of drought

Drought impacts on smallholder farmers result from the interaction between natural events and the demand farmers place on the water supply. The degree of farmers' vulnerability depends on the environmental and social characteristics of the farmer, and is measured by the farmer's ability to anticipate, cope with, resist and recover from drought (Mehdi 2007). There are different impacts of droughts, namely social, environmental and economic, andthese are discussed next.

Social impacts: This refers to impacts such as public safety, health, conflicts between water users, reduced quality of life, inequities in the distribution of impacts and disaster relief and population migration. A significant problem in many countries is population migration, which is often encouraged by a greater supply of food and water elsewhere. Those that migrate usually migrate to urban areas, or areas outside the drought regions. Migration may even be to adjacent countries. The migrants hardly ever return home, even when the drought is less intense, which results in the deprivation of valuable human resources in rural areas. The drought migrants put more pressure on the social infrastructure of the urban areas, leading to increased poverty and social unrest (Wilhite and Vanyarkho 2000).

Environmental Impacts: these results in damage to air and water quality, plant and animal species, forest and range fires andwildlife habitats, degradation of landscape quality, loss of biodiversity, and soil erosion. Some of the effects are short term, and conditions return to normal after or at the end of the drought period. Other environmental effects last for a long period of time, which may evenresultin them becoming permanent. For example, through the loss of wetlands, lakes and vegetation, the wildlife habitat may be degraded. However, many species eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may possibly lead to a more permanent loss of biological productivity (Wilhite and Vanyarkho 2000).

Economic impacts: Many economic impacts occur in agriculture and other related sectors because of the reliance of these sectors on surface and groundwater supplies. In addition to losses in yields from crop and livestock production, drought is associated with insect infestations, plant disease, and wind erosion. The occurrence of forest and range fires increases substantially during extended periods of drought, which in turn places both human and wildlife populations at higher levels of risk (Wilhite and Vanyarkho 2000).

Many of the impacts identified as economic and environmental have social components as well, and in this study the focus is on drought impacts in general.

2.1.2.1 Impact of drought on food security

Food insecurity is the inability of people to access sufficient food for their needs, and it is one of the most severe impacts of drought. In South Africa, many households experience continued food insecurity, malnutrition and unemployment during periods of drought. Approximately 14.3 million South Africans are vulnerable to food insecurity at any given time (Food Pricing Monitoring Committee 2003). Food alone cannot be the only key point in a country confronted with numerous compounding factors that increase food insecurity – situations that are all particularly aggravated during a drought period (Vogel and Smith 2002).

Drought is an important factor in increasing food insecurity, and is strongly linked to periods of vulnerability as a resultof climate stress. Therefore, assessments of food security require broader, conceptual analyses to deal with the causes of vulnerability. Food security assessments should be integrated into related regional assessments of global environmental change to improve the understanding of vulnerability (Vogel and Smith 2002). Food security is a fundamental human right, therefore in order to ensure that everyone has access to basic food at affordable prices, the government has a great responsibility during periods of drought to reduce vulnerability (Food Pricing Monitoring Committee 2003). There is much work that still needs be done with regard to food provision and related market factors, such as the price of staple foods, especially during drought (Food Pricing Monitoring Committee 2003).

2.1.2.2 Impact of drought on food prices

Another impact of drought on the economy that has a major implication for food security is the increase in food prices. A very important staple food for low-income people is maize, and these people are therefore seriously affected by price unpredictability during droughts. For low-income groups, malnutrition and hunger occur during periods of high prices, as they cannot afford the higher prices of food (Chabane2002). The unpredictability of price changes can arise mainly because of two factors. The first is due to unpredictability in natural conditions, such as weather, disease and pests reducing the total crop yield, thus increasing prices. The second occurs because of a gap between planting decisions and the harvesting of crops. Government intervention to cut back price fluctuations is therefore common in industrialised and developing countries, due to the natural instability of agricultural markets (Chabane 2002).

One of the contributing factors to higher food prices is the rise in farm input costs, but this is more of a common occurrence in contract farming arrangements. However, rising production costs do affect farmers' decisions to plant or to invest in a particular activity (Food Pricing Monitoring Committee 2003). In other words, if the marginal revenue received falls below the marginal cost of production, farmers may decide against continuing in a particular industry.

The domestic supply will therefore be reduced and higher prices will be the result, causing greater food insecurity concerns that need to be addressed, and this vulnerability will be worsened during drought periods (Food Pricing Monitoring Committee 2003). The uneven effect of higher maize prices on low-income households, and the successive issues of food security during droughts, worsens inequality and vulnerability, and greater steps are required by government to manage and reduce these risky effects. Consumers will suffer, leading to an increase in vulnerability, especially during drought periods (Chabane 2002).

2.1.2.3 Impact of drought on farming income

Another indicator used to assess the impacts of drought is income loss. Reduced farming income has an effect, as retailers and other service providers to farmers face reduced business operations and, as a result, this leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and ultimately a loss of tax revenue for local, state, and federal governments. The prices of food, energy and other products increase as supplies are reduced. For instance, when there are local shortages of certain goods, these goods have to be importedfrom outside the drought-stricken regions to supply the drought-affected areas. Reduced water supply weakens the navigability of rivers and results in increased transportation costs, because products must be transported by alternative means. Hydropower production may also be significantly affected (Vogel, Laing and Monnik 2000).

2.1.4 The 2015/2016 drought in South Africa

One of the main causes of drought in South Africa is a wide variability in rainfall (Mason and Tyson, 2000; Tyson and Preston-Whyte, 2000;Vogel, Laing and Monnik 2000). The El Niño phenomenon accounts for approximately 30% of rainfall variability (Tyson and Preston-Whyte 2000). Events initiated in the South Pacific Ocean change the temperature, pressure and wind fields over Southern Africa. Different conditions are producedduring high and low phases of the El Niño Southern Oscillation (non-ENSO) (Tyson and Preston-Whyte 2000). During the low phase or warm events of the Southern Oscillation, the convergence zone of cloud bands, usually the source of high rainfall, move offshore (Tyson and Preston-Whyte 2000). The influence of the ENSO warm events on rainfall is strongest in the south-eastern parts of the subcontinent. As a result, these ENSO warm events are frequently associated with drought over much of Southern Africa, as was seen with the severe drought of 1991/1992 and, to a lesser extent, in 1997/1998 (Mason and Tyson 2000).

Global drought caused by ENSO may significantly alter a developing country's access to food from donor governments. Research suggests that even though there is a correlation between ENSO events and drought, not all drought events in South Africa can be clarified by these connections (Mason and Tyson 2000; Tyson and Preston-Whyte 2000;Vogel, Laing and Monnik 2000). As a result, nations require drought management that incorporates all aspects of climate variability, not only ENSO-related variations in rainfall (Reason et al. 2005; Wilhite 2000). Drought is a widespread feature of the South African climate (Vogel 1998) and its influences have consequently been straightforward, particularly with respect to the extra defenceless group plus the farming subdivision. The key reason for in South Africa is rain variability (Mason and Tyson 2000;Tyson and Preston-Whyte 2000).

South Africa is a semi-arid to arid country with a highly variable climate and highly constrained freshwater resources. The limited water resources are affected by weather extremes imposed by climate variability and change. Drought, which has a devastating impact in the country, is a recurrent characteristic feature of the country's highly variable climate and weather extremes. It is one of the most disturbing natural disasters worldwide, of which the socio-economic impact tends to be severe in regions with an annual rainfall of less than 500 mm. South Africa's annual average rainfall is about 450 mm, and this makes this country disposed to recurrent droughts. Figure 2.2 shows the recent rainfall data for South Africa (South African Weather Service 2016).

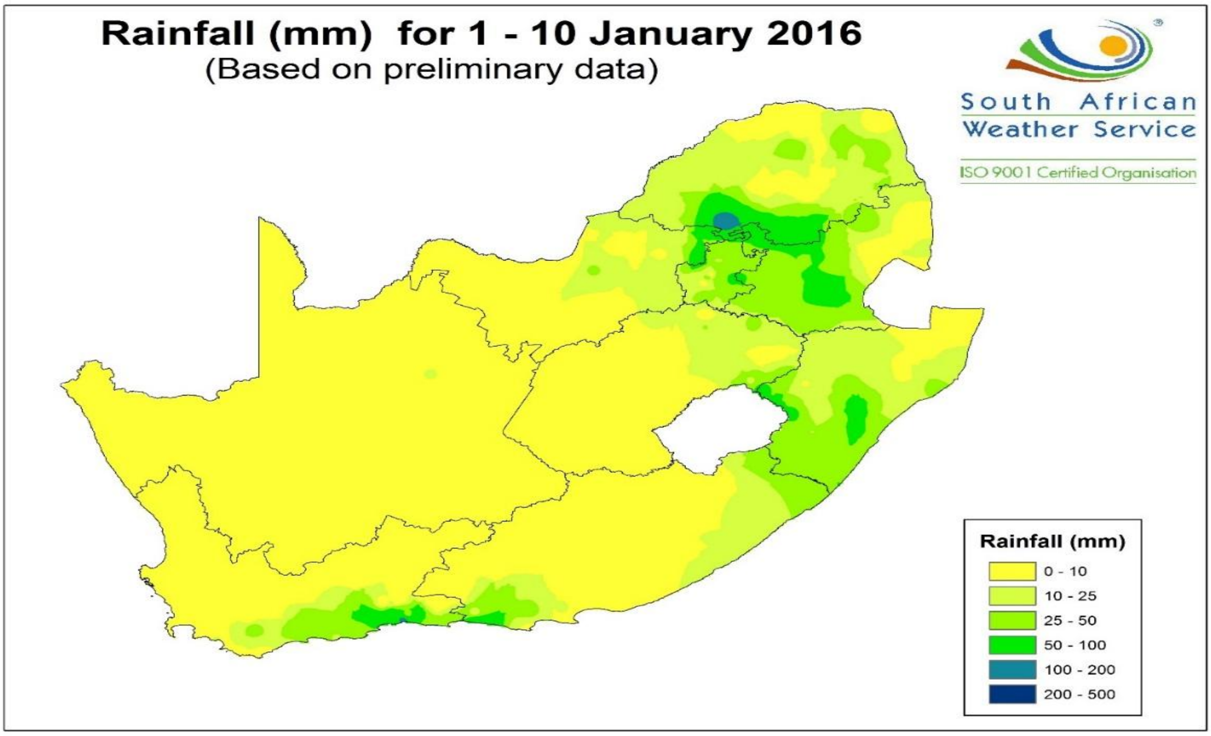

Figure 2.2: Rainfall in South Africa for January 2016

Source: South African Weather Service (2016)

Throughout the twentieth century, droughts occurred across South Africa with great regularity (Vogel 1995). According to the South African Weather Service, any amount of rain that is less than 75% of normal annual rainfall constitutes a meteorological drought. In South Africa, drought days have been experienced over the past 15 years, during which the key part of the nation has received below-normal rain (Mason and Tyson 2000). The main drought years have been 1991/1992, 1997/1998, 2001/2002 and recently 2015/2016 (Mason and Tyson, 2000). The drought in the early 1990s was certainly one of the most severe droughts on record in South Africa due to the effects on food production and vulnerable societies (Vogel 1995).

Although the country has not experienced a drought of similar enormousness as the 1991/1992 drought, new forecasts suggest that the scale, intensity and severity of the 2015/2016 drought was the same or worse than the 1991/1992 drought. The Water Research Commission (WRC) characterised the regionally extensive droughts (REDs) over Southern Africa and examined the mechanisms that produce/control these droughts. The study also examined how climate change may influence the characteristics of REDs in the future. The scenarios project a general increase in the drought coverage, and depending on the scenarios and seasons the percentage of drought area may increase up to 90% in the year 2100 (Water Research Commission 2015).

Approximately 80% of the agricultural land in South Africa is suitable mainly for extensive livestock farming. However, livestock are also found in areas where the animals are kept in combination with other farming enterprises (Department of Agriculture, Forestry and Fisheries 2011). Due to the drought that has affected the country, the area involved in cattle, sheep and goat farming, which is approximately 590 000 km^2, has been affected negatively. This area, which represents 53% of all agricultural land in the country, has resulted in pockets of livestock mortality in the Eastern Cape, while poor livestock conditions were recorded in the Free State province. Commercial sheep farms are also foundin other areas, such as the Kgalagadi, the winter rainfall area and the grasslands of Mpumalanga, as well as the in eastern Free State and in KwaZulu-Natal, with the challenge of wild animals and stock-theft threatening successful farming (Department of Agriculture, Forestry and Fisheries 2016). The past couple of years have seen below normal rainfall in most provinces, affecting the availability of fodder and grazing and resulting in farmers having to supplement with feed. As such, it is logical that a good correlation would exist between rainfall and the size of the national herd, particularly cattle (Department of Agriculture, Forestry and Fisheries 2011).

2.1.4.1 Impacts of the 2015/2016 drought on farmers in the Free State province

According to the annual report of the National Department of Agriculture (1993), the El Nino phenomenon in the Pacific Ocean influences South Africa’s climate particularly in the summer rainfall areas, which include the Free State Province, and this occurrence brings about dryness of the weather, or lack of rainfall (drought), as a result leading to loss of vegetation and economic damage. The Free State province lies in a region that receives less than 500 mm of rainfall per year and plays an important role in the South African economy. Insufficient rainfall, which leads to drought, increases the cost of feed for the farmers, and the few with irrigation schemes have to pay more for irrigation. Therefore, the Free State province was declareda drought disaster area following the unprecedented poor rainfall and heat waves in 2015/2016 (Botai et al.2016).

In the livestock industry, below-normal rainfall has resulted in the depletion of natural grazing veld. With limited grazing capacity, farmers have been attempting to keep nucleus herds alive amidst increasing feed prices. Livestock farmers have also been adversely affected by having to move their livestock to other camps with favourable grazing conditions. Not only do the transport costs put additional pressure on their farming operations, but many farmers have to contend with the risk of physical livestock injury and stress-induced livestock abortions. This is in addition to the reduced calving rate that is a common occurrence in drought years (Agri SA 2016).

The severity of the drought, particularly during the optimal planting window, which is November and December for white maize in the Free State, resulted in a substantial share of maize notbeing planted. Smallholder maize plantings are limited. Based on some of reports, maize plantings in the Free State were as low as 30% of the usual smallholder maize area. Smallholder farmers plant vegetables in a backyard vegetable garden and maize in small plot close to the house for their own consumption as fresh maize (green mealies) or as milled grain. Although many farmers are deficit producers on a subsistence scale (meaning they produce less than what is needed until the next harvest), they tend to sell grain to neighbours or members of the community, partly due to a lack of efficient storage facilities and relatively inflated prices for grain in the rural areas. A decrease in the size or total depletion of farmers’ 'savings accounts' due to the drought, and limited growth potential due to the impact of the drought on next season's calving rates, will have a negative impact on rural households' economic and social resilience in the long run (Bureau for Food and Agricultural Policy 2015).

2.2 Farmers' perceptions of drought

2.2.1 Definition and importance of perception in analysing adaptation decisions

Michaels (2000: 224) defines perception as "the detection of information". There are different ways to gain information through pathways of knowledge and concepts of trust, responsibility and agency (Lorenzoni and Langford 2005). People's behaviour towards an action is, in part, a result of their interpretation of the situation in which the attitude object is situated. For example, factors such as knowledge, media coverage, local weather patterns and perceptions of the responsible organisations are used by people to create their personal views of reality (Dessai and Sims 2010). People therefore use this reality to shape their understanding and behavioural responses, rather than using objective possibilities (Russell and Hampton 2006). However, people's perceptions and attitudes can also differ from their behaviour (Axelrod and Lehman 1993).

Perception is the way smallholder farmers think and behave in relation to climate change and variability (Wehbe et al. 2006). An assessment of the community's perceptions of climate variability-induced hazards can help to uncover the nature of the risk and its underlying factors, and the associated socio-economic consequences. According to Mudombi (2011), the public has a qualitative and complex conception of risk that incorporates considerations such as uncertainty, catastrophic potential dread, controllability, equity and risk to future generations into the risk question. On the other hand, how experts perceive risk is not closely related to the dimensions or the characteristics that underlie it. The experts' point of view is that there are legitimate, value-laden issues underlying the multiple dimensions of public risk perceptions that need to be considered in risk policy decisions (Legesse and Drake 2005).

External risk is determined through scientific analysis, which raises the importance of community-based participatory risk assessment when dealing with natural hazards, while internal risk is determined by individual or community perceptions of insecurity. In order to understand public risk perceptions and risk-reducing strategies, new perspectives and approaches are needed. For example, studies on risk perception have demonstrated that the public's concerns cannot simply be blamed on ignorance or irrationality. Instead, research has shown that many of the public's reactions to risks can be attributed to sensitivity to the technical, social and psychological qualities of hazards that are not well-modelled in technical risk assessments. There are qualities that are beyond control or feared examples, such as uncertainty in risk assessments, perceived inequity in the distribution of risks and benefits, and aversion to being exposed to risks that are involuntary (Legesse and Drake 2005).

It is important to know what the perceptions of the farmers are, because any attempts to elicit adaptive behaviour patterns should come after understanding how climate variability is perceived by farmers and what shapes their perceptions (Shisanya and Khayesi 2007; Slegers 2008; Weber 2010). For example, perceptions and knowledge of climate variability were found to account for adaptive responses and form the foundation of decision-making in a sample of apple growers in India (Vedwan and Rhoades 2001).

Perceptions of drought have been examined in several countries (Habiba, Shaw,and Taeuchi 2012). These perceptions may intervene between human interactions with the environment. Perceptions of the environment and apparent climate adaptation influenced early settlement patterns and public policy (Diggs 1991). Farmers' experiences, perceptions and behaviour have been inter-linkedin the twentieth century. Drought onset is slower and its impacts are more lingering than hazards such as tornadoes, hail and floods (Diggs 1991). This therefore makes drought more difficult to perceive, but because it plays a crucial role in economic survival, most farmers have strong opinions on its magnitude. Some drought perceptions are considered"non-operational". However, farmers living in a semiarid environment noted that farmers in marginal regions perceive drought as unpredictable. A major event, such as drought, can influence future judgement of the probabilities of the same event. A recent drought event can influence people to seek information on protection against that hazard. Thus, judgements on the probabilities of future long-term climate change cannot be determined from past experience. Without real experience of the magnitude and impacts of climate change, people could use more recent short-term climate experiences, such as drought, to aid in the assessment of future climate change (Diggs 1991).

2.2.2 How farmers perceive climate change and drought

According to Diggs (1991), climate change is perceived differently at different levels of conceptualisation, andit varies with age, education, location and livelihood activity. Climate change and drought have been perceived by owner and tenant farmers in both irrigated and non-irrigated villages in North-western Bangladesh.Farmers in Bangladesh perceived a change in climate for 20 to 30 years, therefore the majority of owners and tenant farmers in both irrigated and non-irrigated are left overwhelmed with climate and weather changing over the years. Furthermore, the study noted that drought events occurred more frequently in Bangladesh as a consequence of climate change. Moreover, different farmers perceive that rainy season (rainy season normally occurs from mid-June to mid-August, when farmers expect a short rain shower for seed sowing in Bangladesh).With farmers' perception of rainy seasons, the timing of the rainfall issaid to be decreasing rainfall intensity and number of rainy days are responsible for enhancing drought. In both the irrigated and non-irrigated areas, the long lengths of summer days as well as short length of winter days are recognised as observed climatic changes. For example, Maddison (2006) mentions that a large number of farmers in eleven African countries perceive temperatures to have increased and precipitation to have declined. Regarding the farmers' perceptions and awareness of climate change and drought, farmers in both irrigated and non-irrigated areas are aware of other non-climatic issues that accelerate drought severity.

Bryan et al. (2009) also found that a large number of farmers in Kenya perceived temperaturesto have been increasing over time, and that rainfall has been decreasing. In South Africa, a large number of farmers perceive temperatures to have increased and that there has been a decline in rainfall (Bryan et al. 2009). For the most part, farmers' perceptions of climate change appear to be in line with actual climate data. In Ethiopia, farmers' perceptions of climate change appear to reflect actual temperature and rainfall data obtained from the National Meteorological Services Agency (2001), which shows an increasing trend in temperature and decreasing trend in precipitation between 1952 and 2000.

According to Mahouna, Fadina, and Barjolle (2018), the majority of farmers in South Benin claimed that the climate had changed. There are different changes that comprise the changes in climate observed by the farmers. The main changes that farmers consider as changes that contribute to climate change are: rainfall disturbances (rainfall delays, early cessation, bad rainfall distribution, etc.), shortening of the short dry season, increasing temperature and, sometimes, violent winds and other extreme events such as floods in areas, since agriculture is rain fed and the agricultural calendar is adapted to the rainfall system. It therefore is quite normal for farmers to perceive any change in the rainfall regime. However, disturbances in precipitation are perceiveddifferently because it is the most common change in climate change (Mahouna, Fadina, and Barjolle 2018).

Farmers in different provinces in South Africa perceive climate change differently (Benhin 2006). Farmers are of the opinion that there have been some changes in the climate over the years, including higher temperatures, delays in the timing of the rain and a reduction in the volume of the rain. Perceptions vary somewhat in the different provinces (Benhin 2006). In the Eastern Cape, farmers have noticed long-term change in the pattern of temperature and rainfall over the years. The farmers think there has been a general increase in temperature and a decline in the volume of rainfall. Summers are becoming longer and hotter and winters shorter and warmer. However, there are other farmers in the province who do not perceive that there has been a change in climate. For them, the changes that have occurred are not long-term changes but rather a consistent occurrence over a ten-year cycle in the climate, where the province experiences droughts and warmer temperatures every tenth year. Farmers in the Free State have perceived a change in the climate of the province. For these farmers, it has become windy, dusty, drier and hotter. Temperatures are increasing and the volume of rainfall has decreased (Benhin 2006).

Farmers' perceptions about drought are mostly linked to rainfall-related issues. The majority of farmers in rural Northeastern Thailandconsider drought as the unpredictable distribution of rainfall,for instance when there is no rain for a stated period of time, a late start to the rainy season and when it stops raining early (Polthanee and Promkhambut 2014). Despite this rainfall-related interpretation, the farmers believe that crops/plants that dry up or burn, and seeds/cuttings that do not evolve are also considered as drought. However, some farmers believe that drought is the consequence of the low water-holding capacity of the soil which cannot support plant growth. Although other definitions of drought include insufficient feed for livestock, low crop yields (Polthaneeand Promkhambut 2014). Some farmers perceive drought as a natural phenomenon, while others perceive it as a mismanagement of water resources by the responsible authority (Udmale et al. 2014).

The most common perception of drought is that it is a disaster. It is also perceived as a hazard. Hazards are described as physical or human-made phenomena that may cause physical damage, economic loss or threaten human well-being in interaction with conditions of vulnerability (Von Kotze and Holloway 1996). It has also been perceived as a business risk and not a natural disaster; for example, climate change is perceived as a risk to farm businesses as well as physical and social resources (Hayman and Cox 2003). Drought is also perceived as a risk to the efficiency of the rural sector and hence the national economy (Hayman and Cox 2003; O'Meagher 2003). It is recognised as a contributing factor to suicide and illness in rural areas, and thus a risk to the welfare of rural families and communities. It is the crucial point for operational problems of farm size, the cost-price squeeze and the fragile interdependence of rural communities. However, Australia's Prime Minister, Paul Keeping, pointed out in 1994 that "drought and climate variability are part of the natural environment and do not constitute a natural disaster" (Hayman and Cox2003; 163).

Some of the studies in Australia, for instance, have observed drought as a consequence of not only low rainfall but as a rainfall deficiency as well, and a risk in its own right. Drought and seasonal fluctuation are perceived as normal, recurring phenomena that people and farmers need to plan for, just like any other business risk (Hayman and Cox 2003). Apart from the fact that drought is perceived as a risk in general, it is specifically a risk to food security. More importantly, it is something that must be battled with, with a plan of action for attack – taking into consideration that "drought grips, creeps, bites and decimates the land and people who are drought smitten, desperate and ruined" (Hayman and Cox 2003; 163).The perception of drought by the state is to as those of the people who are directly affected by drought and who constitute social groups (Akpalu 2005). Rural households, who are most directly affected by drought, generally perceive drought as a "trait of life". The drought risk has historically been viewed not only through kinship bindings, but also from a very rational point of view, with the overall objective to extend risk. Households used to perceive drought as a problem that concerned the family, ward or tribe. It is perceived "as a group problem which was solved by consensus within the group" (Krüger 1999; 181-182).

2.2.3 Factors influencing farmers' perceptions

Studies suggest that farmers' perceptions of the adoption of soil fertility-management practices are strongly linked to their experiences and knowledge about the practices (Meijeret al. 2015; Reimer et al. 2012). For instance, Meijeret al. (2015) argue that the knowledge farmers have about a new practice closely relates to their perceptions of such a practice, which together frame the farmers' attitudes towhether or not to adopt the practice. Ervin and Ervin (1982) argue that farmers' personal characteristics, such as age and education, also play a critical role in framing their perceptions of adoption (Bwambale 2015).

Risk influences farmers' attitudes to and perceptions of adoption behaviour (Ghadim, Pannell, and Burton 2005). Risk-averse farmers easily adopt new conservation practices that are perceived to reduce risk (Pannell et al. 2006) and are in line with their economic motivations and goals (Greiner, Patterson,and Miller 2009). In addition, personal farmer characteristics, such as wealth (livestock, land, cash), past farming experience as well as age, greatly influence their risk attitudes and perceptions (Ghadim, Pannell, and Burton 2005).

The education level of farmers is used to determine if the education of the farmers has an influence on how they perceive the amount of rainfall at the start of a farming season. According to Mamba (2016), education level influences perception. Farmers who correctly perceivedthe amount of rainfall expected at the beginning of the farming season are those who either have training in certain skills, or those who went up to tertiary level,orat least secondary level, in their education. However, the majority of farmers without any form of education wrongly perceive the amount of rainfall as low or average when,in fact,it is actually plenty or above average (Mamba 2016).

According to Mamba (2016), the age and education level of farmers influence how they perceive climate variables. This is consistent with Dhaka, Chayal, and Poonia (2010), who also observed that farmers' education level and age influence their perception of climate variability and change. Dhaka, Chayal, and Poonia (2010) observed that age is directly linked to farming experience. Old farmers possess indigenous knowledge on how to perceive climate variables, particularly the amount of rainfall at the beginning of each farming season. Such knowledge is not possessed by younger farmers, and needs to be passed on to the young generation to help them correctly perceive important climate variables such as rainfall. This should be the focus of agricultural policies aimed at improving food production. With respect to education, it can be observed that education also has a role to play in influencing the way farmers perceive climate change and variability, which is consistent with Kamruzzaman's (2015) findings that farmers with a higher level of education perceived environmental factors and climate variables correctly, and vice versa. This means that efforts to help farmers perceive correctly also need to focus on improving the level of education of farmers, particularly to equip then with skills relating to farming. This means that, to help improve how farmers perceive climate variables, education (both formal and informal) must be emphasised (Mamba 2016).

Access to extension services and weather information affects how farmers perceive climate variables. Those farmers with access to extension services and weather data tend to correctly perceivethe amount of rainfall at the start of a farming season. The study by Legesse, Ayele and Bewket (2012), conducted in the Doba district in Ethiopia, found that the frequency of extension contact and training were the determining factors influencing perception and adaptation strategies, which is similar to a study by Kamruzzaman (2015), conducted in the Sylhet Hilly Region in Bangladesh, who also observed that access to weather information influences farmers' perceptions. This means that access to extension services needs to be improved as a step towards improving farmers' perceptions of climate change and variability (Mamba 2016).

According to Bryan et al. (2009), gender is another important factor that influences how farmers perceive climate change and variability. This is not surprising for Swaziland, because women are the most active in farming compared to men. It therefore is expected that, based on their level of engagement in farming activities, which gives them experience, women are well positioned to perceive correctly the amount of rainfall at the beginning of each farming season, which is what they do every year (Mamba 2016).

2.2.4 Perception as a factor influencing farmers' choice of coping/adaptation strategies

According to Adesina and Zinnah (1993), farmers' perception of technology-specific traits has been a major factor conditioning adoption behaviour. This strongly confirms the hypotheses that farmers' perceptions of the attributes of agricultural technologies determine their observed adoption choices. Therefore, it strongly suggests that farmer perceptions of technology-specific characteristics should be considered in evaluating the determinants of adoption decisions relating to agricultural technologies (Feder, Just, and Zilberman 1985).

The study done by Shongwe, Masuku, and Manyatsi (2014) reveals that perceptions of households towards climate change, high food prices, access to credit and land category significantly influence the choice of not adapting to climate change compared to adapting using drought-tolerant varieties and shifting planting time. This suggests that, when households perceive a change in climate, the probability for not adapting becomes reduced compared to that of adopting. The perception of high food prices reduces the probability for not adapting to climate change compared to adapting. This is because households will adapt to increase crop production so that they will be able to produce their own food to avoid high food prices in the markets (Shongwe, Masuku, and Manyatsi 2014).

2.3 Vulnerability to impacts of drought

2.3.1 Definition and types of vulnerability

According to Guillaumont (1999; 4), "vulnerability means the risk of being harmed (negatively affected) by unforeseen events", therefore vulnerability can broadly be defined as the potential for loss due to a hazard such as drought, or insecurity in the face of a changing environment or an economy's proneness to downside risks. Vulnerability shows the degree of susceptibility of society to a hazard, which could vary either as a result of variable exposure to the hazard, or because of coping abilities (Cordina 2004). The magnitude, duration, impact, frequency and rapidity of onset of natural hazards such as drought characterise the level of vulnerability (Cutter 1996). The more vulnerable a community is, the greater the physical and economic costs when a hazard occurs (Vogel 1998). The local physiographic, historic and socioeconomic influences of a region are highly significant factors in understanding people's vulnerability to drought (Boko et al. 2008).

Environmental, economic and social factors determine people's level of vulnerability and the extent of their capacity to resist, cope with and recover from hazards. The different types of vulnerabilities are discussed as:

Social vulnerability: is defined as the exposure of individuals or groups to pressure as a result of climate change impacts and related climate extremes (Adger 1998). Pressure involves the disruption of groups' or individuals' livelihoods and involuntary adaptation to the changes in thephysical environment. Vulnerability therefore can be explained by a combination of social factors and environmental risk, where risk is the physical aspects of climate-related hazards exogenous to the social system (Adger, Arnell and Tompkins 2005). Social vulnerability in general includes disruption of livelihoods and loss of security and, for vulnerable groups, is often persistent and is related to the underlying social and economic situation. Then again, vulnerability also encompasses access and entitlement to resources, the power relationships in the relevant institutions in state and markets, and the cultural and historical context (Guillaumont 2009). In this sense, the hazard is specific and the possible impacts are closely influenced by the characteristics of social vulnerability. Adger et al. (2005) argue that, even though social vulnerability is not a function of a hazard, it depends on the type of hazard to which the community is exposed. For example, while the type and quality of housing is an important factor in vulnerability, it is not as important regarding vulnerability to drought. Therefore, vulnerability is to some extent specific to a particular hazard. However, pertaining to social vulnerability, there are a number of factors that are generic to most hazards, such as health and inequitable access to resources (Adger et al. 2005).

Economic vulnerability: the concept of economic vulnerability emerged from the study of the specific weaknesses of communities that would account for increased risks to economic growth and performance without necessarily being reflected in per capita output levels. Brigulio et al. (2009) define economic vulnerability as the exposure of an economy to exogenous shock because of its economic openness. Guillaumont (1999) states that economic vulnerability can be viewed as an economy's vulnerability to downside risks. Economic vulnerability implies an increase in sensitivity to shocks, and relatively greater susceptibility to shocks of an adverse nature. Economic vulnerability results from three main determinants: the size and likelihood of shocks, the exposure to these shocks, and the resilience or the capacity for reacting to them (Guillaumont 2009).

Environmental vulnerability: is defined as “the degree of sensitivity to environmental change by external impacts” (Kværner, Swensen, and Erikstad 2006; 512). Environmental vulnerability to drought refers to the environment’s susceptibility and, more specifically, the susceptibility of the vegetation to the impact of a severe drought. Soil degradation through wind and soil erosion, bush encroachment and the extinction of certain species could be the result of severe droughts. Locusts in combination with drought could damage the vegetation cover to such an extent that it takes many years to recover to its original state (Jordaan, Sakulski,and Jordaan 2013).

2.3.2 Drought occurrence andfarmers’ vulnerability

About 60% of Sub-Saharan Africa (SSA) is said to be vulnerable to drought, with 30% of it being estimated to be highly vulnerable (International Fund for Agricultural Development 1994, cited in Benson and Clay 1998). It is estimated that about 65% of South Africa receives less than 500 mm of rain per year, which makes the country vulnerable to drought (Backeberg and Viljoen 2003; Van Zyl, McKenzie and Kirsten 1996; Wilhite 1993), which implies that most farming operations in South Africa take place under arid and semi-arid conditions (Wilhite 1993). Regardless of this status quo, a greater concern for the farming community is the projected broad reduction of about 5% to 10% in the annual rainfall in the summer rainfall region (Department of Environmental Affairs and Tourism 2004).

Both small-scale and commercial farmers have had to struggle during drought occurrences (Groenewald and Nieuwoudt 2003). The agricultural industry is becoming more concentrated in the hands of large commercial farmers, since small-scale farmers are surrendering to their vulnerability to drought and are losing their livelihoods as well as their own best source of food (Makgetla and Watkinson 2002). The occurrence of drought affects smallholder farmers in different ways, such as:

Poverty and lack of access to resources: The direct association of poverty with access to resources, which affects both baseline vulnerability and coping with the impacts of extreme events, makes it an important aspect of vulnerability. It is argued that the incidence of poverty, as observed through the measurable indicator of income, is a relevant proxy for access to resources in its multi-faceted forms. Since resources are mediated through property rights and access to them, resources and the wealth in them do not constitute security. Access in this context can be taken to mean the ability to involve an individual, family, group or community to use resources which are directly required to secure a livelihood. Access to those resources is always based on social and economic relations (Blaikie, Cannon and Wisner 1994). However, it is difficult to directly observe and measure access to resources, and in that way it is similar to the concept of entitlement to resources (Fine 1997; Leach et al. 1997; Sen 1981). According to Nortonet al. (1993), access to resources is regarded as one of the main contributing factors to vulnerability.

Unemployment: The reason for unemployment is due to a decline in agricultural production and fewer agricultural producers due to bankruptcy (Jordaan 2012). Unemployment is an important indicator, because it affects farmers and the community at large. Communal farmers are more vulnerable during drought if most of their income is from farming andthey do not have other sources of income. Paavola (2008) shows that one of the main influencing factors in farmers' vulnerability is income. During drought, farmers' incomes decrease due to unemployment and this makes it difficult for them to mitigate the adverse impact of drought. The farmers are in the “first line of defence” from the impact of drought, and they are the ones who directly lose income and profits. This could affect the income streams and job security of farm workers and the economies of small rural towns that depend on the economic wellbeing of the agricultural sector (Jordaan 2012).

Credit risk: According to the Department of Agriculture and Rural Development (2011), the debt ratio represents the level of debt to assets for a farm. It is a good indicator of the level of financial risk associated with the farm. Small-scale farmers tend to start their business with off-farm income (loan/credit) and this makes it difficult for them to repay their debt during drought. Therefore, the farmer will be more vulnerable to drought. As more money will be needed to proceed with farming business. To make matters worse, if the farmer is not making enough money it becomes difficult to repay farm and personal debts, and this can affect his/her borrowing capacity (Austin 2008).

Inequality: Vulnerability to climate extremes is not only determined by the formal institutional arrangements that organise warning, planning and other services, but also by the institutions of the wider political economy. The relationship between inequality and vulnerability is not unidirectional, however, since it is argued that under certain circumstances inequality facilitates the provision of services for the good of communities by those with cumulated assets (Adger 1998). The collective aspects of vulnerability involve interaction at various levels, from a single community to the nation. The level of infrastructure, institutional preparedness and other factors important in the implicit collective vulnerability of a nation, region or community may not be accurately reflected in measurement of the economic activity. Increasing inequality over time within a population, or between different parts of the population, increases collective vulnerability to climate change. Also, inequality and vulnerability linkages are associated with relationships between inequality, diversification of income sources and poverty, which in other words means that inequality affects vulnerability directly through constraining the options of households and individuals when faced with external shock, and indirectly through its links to poverty and other factors (Adger 1998).

In order to address and reduce farmers' vulnerability to drought, there is the possibility of strategies per household, as long as they create income, well-being, security and re-productive goals (Adato and Meinzen-Dick 2002). The livelihood strategies can be changed into livelihood outcomes that will be more proactive in relation to the farmers' needs during drought periods (DFID 1999).

2.3.3 The sustainable livelihoods framework and farmers' adaptation behaviour

2.3.3.1 The sustainable livelihood framework (SLF)

According to the DFID (2000; 14), "[a] livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base". Therefore, the livelihood comprises the capabilities, assets and activities required for a means of living. Figure 2.3 shows the sustainable livelihoods framework (SLF) developed by the Department for International Development (DFID). The SLF framework starts by identifying a vulnerability context that describes the external environment (political, historical, social, cultural, etc.) in which a community is situated.

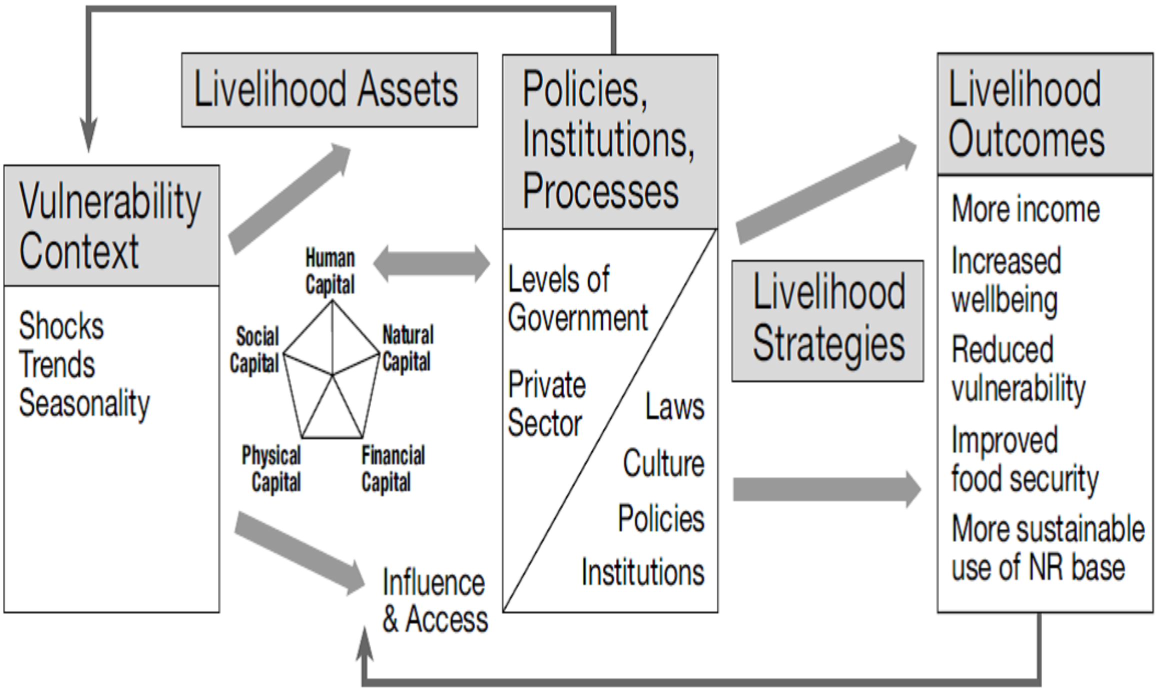

Figure 2.3 The sustainable livelihood framework (SLF)

Source: DFID (2000).

The Sustainable Livelihood Framework depicts stakeholders as operating in a context of vulnerability, within which they have access to certain assets. Assets gain weight and value through the prevailing social, institutional and organizational environment (policies, institutions and processes). This context decisively shapes the livelihood strategies that are open to people in pursuit of their self-defined beneficial livelihood outcomes (Kollmair and Gamper, 2002; 5).

Vulnerability context

The vulnerability context frames the external environment in which people exist. Critical trends as well as shocks and seasonality, over which people have limited or no control, have a great influence on people's livelihoods and on the wider availability of assets. Not all of the trends and seasonality must be considered as negative. Vulnerability emerges when human beings have to face harmful threat or shock with inadequate capacity to respond effectively. The difference between *risk* and *vulnerability* is of crucial relevance for assessing causes of poverty. Risk is defined as the likelihood of occurrence of (external) shocks and stresses plus their potential severity, whereas vulnerability is the degree of exposure to risk (hazard, shock) and uncertainty, and the capacity of households or individuals to prevent, mitigate or cope with risk (Department for International Development (DFID) 2000; 3).

A vulnerability context "describes the events that influence people's ability to pursue livelihoods including sudden shocks, longer-term trends or cyclical occurrences and stresses" (ZENID 2002). The International Fund for Agricultural Development (IFAD) describes the vulnerability context as "difficult or impossible to change and must be 'coped' with instead". It is essential to understand the context because it directly impacts the kind of assets that are available to people.

Livelihood assets

As the livelihoods approach is concerned first for all with people, it seeks to gain an accurate and reasonable perception of people's strengths (known as "assets" or "capitals" in the model). It is important to analyse how people make an effort to convert these strengths into positive livelihood outcomes. The approach believes that people have a need for a variety of assets to achieve positive livelihood outcomes. Therefore, the SLF identifies five types of assets or capitals upon which livelihoods are built, namely human capital, social capital, natural capital, physical capital and financial capital (see Figure 2.4). The SLF uses multiple indicators to assess exposure to natural disasters, such as drought and climate variability, and the social and economic characteristics of household that affect their adaptive capacity (Scoones et al. 2017).

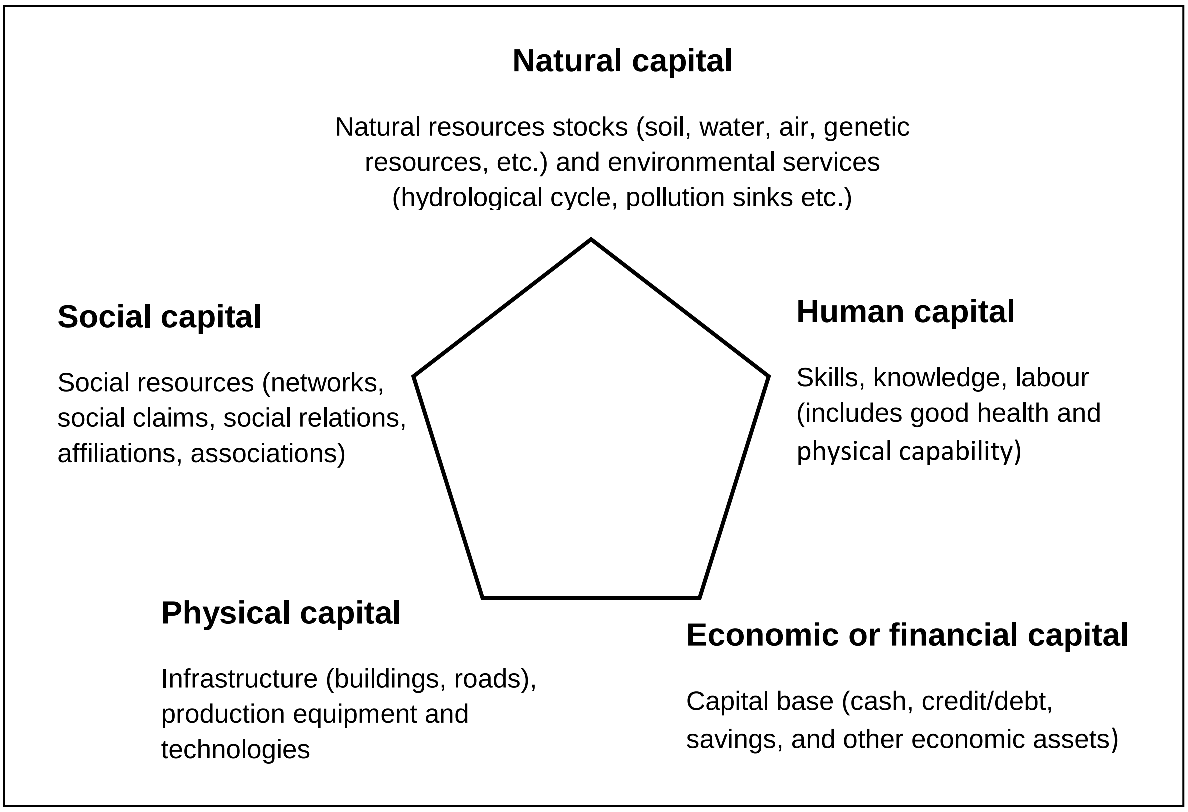

Figure 2.4 The five capitals of the sustainable livelihoods framework

Source: Morse et al. (2009).

The ability to pursue different livelihood strategies is dependent on the basic material, tangible and intangible assets that people have in their possession. Figure 2.4 shows the five capitals of the sustainable livelihood framework (Scoones et al. 2017), which are discussed below.

Natural capital: “this refers to resource bases found in nature that are not only essential for livelihood creation but to sustain life itself and includes clean air, trees and forests, water, land and wildlife. DFID also includes the “flows and services” that are derived from the natural resource bases, such as nutrient cycling, erosion protection and waste assimilation, in its definition of natural capital” (DFID 1999: 6).

Physical capital: “this refers to basic infrastructure, including affordable transportation, secure shelter and buildings, adequate water supply and sanitation, clean and affordable energy and access to information, as well as producer goods, which are the tools and equipment that people use to function more productively like vehicles, computers and farming equipment” (DFID 1999: 6).

Economic or financial capital: "this refers to the cash flows, savings and investments that support livelihoods". According to the DFID, financial capital is "probably the most versatile of the five categories of assets", mainly because it can be "converted into other types of capital with varying ease depending upon transforming structures and process" (DFID 1999: 7).

Human capital: "this refers to the skills, knowledge, ability to labour and good health that enable a person to pursue different livelihood strategies and achieve their livelihood objectives" (DFID 1999: 7). The "DFID stresses that human capital can be bolstered directly, for example through resource transfers for building schools and hospitals and indirectly, by promoting job creation initiatives, thereby bolstering the value of education in the eyes of the community" (DFID 1999: 7).

Social capital: "refers to the trust, mutual understanding, and shared values and behaviours that bind the members of human networks and communities and make cooperative action possible" (Cohen and Prusak 2001). Unlike other assets, social capital is said to be "a mechanism to correct market failures, especially those associated with access to information, a way in which checks and balances can be placed on government action and a means through which policy can be influenced" (May, Roerson, and Vaughan 2000: 8).

Transforming structures and processes

Transforming structures and processes represents the institutions, organisations, policies and legislations that shape livelihoods. The reason they are important is because they operate at all levels and effectively determine the access to, terms of exchange between different types of capital, and returns to any given livelihood strategy (Keeley 2001; Shankland 2000). Policies, institutions and processes have an impact on how people use their assets in pursuit of different livelihood strategies. The transforming structures and processes section in the diagram refer to both informal and formal institutions and organisations that outline livelihoods by influencing access to assets, livelihood strategies, vulnerability, and exchange terms. They may transpire at multiple levels, from the household to the community, national and even global levels. The public and private sectors, civil society and community institutions are all relevant considerations; including laws as well as culture (Adato, 2002).

Livelihood strategies

Livelihood strategies comprise the range and combination of activities and choices that people make in order to achieve their livelihood goals. They are understood as the dynamic processes in which people combine activities to meet their various needs at different times. Different household members might live and work at different places, permanently or temporarily. According to the DFID (1999: 3-4), “livelihood strategies are directly dependent on asset status and policies, institutions and processes. Hence that poor people compete and that the livelihood strategy of one household might have an impact (positive or negative) on the livelihood strategy of another household”. When considering livelihood strategies and issues connected to the sustainable livelihoods framework in general, it is important to recognise that people compete (for jobs, markets, natural resources, etc.), which makes it challenging for everyone to achieve simultaneous improvements in their livelihoods. The poor are a mixed group, with different priorities in a limited and therefore highly disputed environment. Compromises are therefore often essential. An application of the SLFpresents sensitivity issues in a different way (Kollmair and Gamper 2002).

Livelihood outcomes

According to the DFID (1999), livelihoodoutcomesare defined as the achievements or outputs of livelihood strategies that include more income, increased well-being, reduced vulnerability, improved food security and a more sustainable use of natural resources. Livelihood outcomes are the aims of a particular group, as well as the extent to which these are already being achieved (DFID 1999). Outcomes also include a strengthened asset base, reduced vulnerability, and improvements in other aspects of well-being, such as health, self-esteem, sense of control, and even maintenance of cultural assets, and as a result have a reaction effect on the vulnerability status and asset base (Adato 2002).

2.3.3.2 Farmers’ livelihoods and adaptation in a climate change vulnerability context

Farmers’ livelihoods are composed in complex ways, with multiple and dynamic portfolios of different activities that are often improvised as part of an on-going ‘performance’ (Scoones et al. 2017). According to Scoones (1998), people must combine the ‘capitals’ that they have access to and control overin order to create livelihoods. Thesemay be made up of personal capabilities, tangible assets (e.g. stores and material resources) and intangible assets (claims and access) (Chambers and Conway 1992). The vulnerability of households to climate change is a function of biophysical and socio-economic factors and institutional factors (Cooper et al. 2008; Ncube et al. 2015).

At the household level, an index used to assess livelihood vulnerability should provide a clear indication of the capabilities, assets and activities required for a sustainable means of living (Chambers and Conway, 1992). When a livelihood can cope with and recover from shocks, and maintain or enhance its capabilities and assets while undermining the natural resource base, then it is considered sustainable. Livelihood vulnerability assessment can provide information that helps with decision-making at two adaptation and planning levels. It looks at the five types of household assets, which are social, natural, financial, human and physical capital, that make use of multiple indicators to assess exposure to natural disasters and climate variability, and the social and economic characteristics that affect adaptive capacity (Shah and Dulal 2015).

In understanding vulnerability to climate change, the sustainable livelihoods framework is particularly relevant because it analyses both the key components that make up livelihoods, and the contextual factors that influence them. The framework is for understanding people's access to assets that include natural, human, social, physical and financial capital. Other assets are also used in analysis, such as information, cultural/traditional and institutional assets. There are different ways in which the sustainable livelihoods approach can be used in climate change vulnerability analysis. Examples are building social capital, increasing the flow of information about new technologies, andimproving access rights to alternative grazing areas during drought. The asset-based framework helps identify ways in which capital can be used to cope in the short term, or ways it can be used to prepare solutions for future problems (e.g. in financial capital to purchase crop insurance) and how to substitute for capital assets to adapt to changing circumstances, e.g. substituting natural for social capital by moving livestock to unaffected areas during drought (Reed et al. 2013).

The current adaptive capacity of households is shown by their human, physical, financial, natural and social capital. These forms of capital influence their vulnerability. Depending on each farming household's needs and the nature of their shocks, they can convert the capital from one form into another. Farmers in poor households have little capital and are therefore more vulnerable to the impact of climate change (Eriksen and Silva 2009). In order to cope with external shocks such as drought, the households need to consider external assistance (Ncube et al. 2015). Farmers' human capital consistsof thenumber of available labourers, i.e. people who are capable of working, grazing experience years, and number of years of education/schooling; material capital consists of various kinds of household assets, such as living and grazing facilities and the number of livestock owned by the household; natural capital consists of pasture area and grassland productivity; financial capital consists of annual income from livestock grazing and off-pasture work; and social political consists of social connections, e.g. neighbours, friends, relatives. Overall, climate risks, institutional contexts, market accessibility and the endowments of household capital collectively affect farmers' livelihood adaptation behaviours, and constraints in any of the factors can cause maladaptation to climate change (Cooper et al. 2008).

Vulnerability to climate change differs across space and time due to a number of contributing factors. For example, a tropical ecosystem will be less sensitive to a decrease in rainfall than a fragile, arid or semi-arid one, due to the successive influences on water flows (Adu et al. 2018). A lack of resources for adaptation will result in critical challenges for farming communities struggling to adapt to climate change. The Sustainable Livelihoods Approach addresses the issues of sensitivity in an adaptive capacity to climate change (Hahn, Riederer, and Foster 2009).

The relationships between capitals are explored in a context of changing climate and landuse. In understanding sustainable livelihoods, the values of different assets are equally important and cannot be substituted. However, this does not mean that there is isolation from each other amongst the different capitals. They might be related to each other in a sense that none of them can be excluded from a sustainable livelihood. However, when people adopt new livelihood strategies in response to vulnerability context changes, the value of some assets decreases while the value of others increases. This means that, in order to avoid increased vulnerability, people often need to transfer the value of one asset to another. Therefore, if vulnerability is defined as the inability of an individual or group to organise and transfer assets when conditions are changing, an assessment of the assets possessed by a particular individual or group at any given time will provide the first indication of vulnerability (Knutsson and Ostwald 2006).

Climate-induced variability increases the vulnerability of rural livelihoods and reduces the ability of households to deal with risks, shocks and stresses. Since these households have limited assets, they are at increased risk and their ability to cope is limited. Therefore, in order to reduce livelihood vulnerability, critical levels of natural capitals must be provided (Keshavarz, Maleksaeidi, and Karami 2017). At the community level, local perceptions and experiences of climate extremes can help in identifying the factors that enable or constrain the ability of communities to respond, recover and adapt to climate change. A higher dependence on agricultural income represents a greater vulnerability of the livelihood strategies component (Hahn et al. 2008).

2.4 Coping and adaptation strategies to drought

2.4.1 Adapting and coping with climate change and drought

Coping strategies can be classifiedas pre-drought and post-drought strategies. The classification depends on whether these strategies can help reduce the risk or alleviate the impact on the shortfall in the production in a certain period (Hazelton, Pearson, and Kariuki 1994). Several drought-coping mechanisms are in use around the world. According to Hazelton, Pearson, and Kariuki (1994), Panley (2009), Tideman and Khatana (2004) and Wilhite (2000), the use of drought-coping strategies is a major accomplishment that enables or provides the community with some capacity to cope. According to Hazelton, Pearson, and Kariuki (1994), drought-coping strategies are made up of a number of drought-mitigation measures. Drought-mitigation measures comprise ecological, social, environmental and technological measures that aim to alleviate drought impacts and equalise losses (Holm and Morgan 1985). Therefore, adaptation to climate change includes all adjustments in behaviour or economic structure that reduce the vulnerability of society to changes in the climate system (Smith, Ragland, and Pitts 1996).

Adaptation refers to adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change. Adaptations vary according to the system in which they occur, who undertakes them, the climatic stimuli that prompt them, and their timing, functions, forms and effects. In an unmanaged natural system, adaptation is autonomous and reactive; it is the process by which species and ecosystems respond to changed conditions. Adaptations consciously undertaken by humans include those in economic sectors, managed ecosystems, resource use systems, settlements, communities, and regions. In human systems, adaptation is undertaken by private decision makers and by public agencies or governments. Adaptation depends greatly on the adaptive capacity or adaptability of an affected system, region or community to cope with the impacts and risks of climate change (Smith, Ragland, and Pitts 1996).

The adaptive capacity of communities is determined by their socioeconomic characteristics. Enhancement of adaptive capacity represents a practical means of coping with changes and uncertainties in climate, including variability and extremes. In this way, the enhancement of adaptive capacity reduces vulnerabilities and promotes sustainable development (Burton, Rigby, and Young 1998). According to Sathaye and Christensen (1998) and Bruin (2011), adaptation strategies can eitherbeproactive or anticipatory, depending on whether they take place before or after climate change. Reactive adaptation strategies address the effects of climate change after it has been experienced, while proactive adaptation strategies are engaged in the anticipation of climate change.

According to Burton, Rigby, and Young (1998) there are five generic objectives of adaptation, which are:

1) Increasing robustness of infrastructural designs and long-term investments, for example, by extending the range of temperature or precipitation, a system can withstand without failure and by changing the tolerance of loss or failure (e.g., by increasing economic reserves or by insurance).

2) Increasing the flexibility of vulnerable managed systems,for example, by allowing mid-term adjustments (including change of activities or location) and reducing economic lifetimes (including increasing depreciation).

3) Enhancing the adaptability of vulnerable natural systems, for example, by reducing other (non-climatic) stresses and removing barriers to migration (including establishing eco-corridors).

4) Reversing trends that increase vulnerability (also termed "maladaptation"), for example, by introducing setbacks to development in vulnerable areas such as floodplains and coastal zones.

5) Improving societal awareness and preparedness, for example, by informing the public of the risks and possible consequences of climate change and setting up early-warning systems.

2.4.2 International research on adaptation/coping strategies used by farmers

Farmers make decisions on adaptation/coping strategies based on choices they consider important. According to the study by Mutekwa (2009) on climate change impacts and adaptation in the agricultural sector in Zimbabwe, livelihood diversification has increasingly become an important adaptation strategy in Murowa ward. There are more climate change-related migrations to the nearest towns, and to other distant towns in the country. Some young people are going as far as South Africa and Botswana, resulting in their families and other close relatives depending on remittances to supplement agricultural incomes, as well as during periods of food shortages. Soil and water conservation strategies, such as water-harvesting activities, which currently are practised by a few of the smallholder farmers, are intensified by agricultural extension officers and NGOs. Other adaptation strategies include growing legumes (such as beans) towards the end of the rainy season, when cereals fail, mainly due to excessive rainfall, and the application of more fertilisers when nutrients are heavily leached from the soils. Legumes mature rapidly and provide nutrition (Mutekwa 2009).

Bryan et al. (2013), in adapting agriculture to climate change in Kenya, showthat the main adaptation measures adopted by farmers are different. Changing planting decisions, choosing a new crop or crop variety, and changing planting dates, were the key adaptation measure in all but the arid zone. In arid zones, moving animals, presumably to regions with lower temperature and more rainfall to support grazing, was the key adaptation strategy, followed by changing the crop or the variety (but not planting date), and changing livestock feed. However, in the semi-arid zone, farmers have also increasingly switched from cropping systems to mixed crop/livestock systems, and have planted trees to adapt to climate change. Changing fertiliser application was a primary strategy in the temperate and humid zones, while changing livestock feeding regimes and increasing cultivated land were respectively reported as key strategies (Bryan et al. 2013).

According to Coulibaly et al. (2015), the key coping strategies used by households in Southern Malawi to deal with short-term climate variability and other stressors are ex-post risk management strategies, such as off-farm labour, small businesses and the sale of charcoal and firewood. These strategies are adopted to mitigate the adverse impact of crop failure on farmers' livelihoods. For the ex-ante options, only farm irrigation is a main strategy adopted by households. Changing crop type/variety and diversifying crop production are adopted by a negligible proportion of farmers to adjust to crop failure. The finding that the ex-post risk management strategies are the dominant coping alternative used by households is in line with other study findings in the rest of Africa (Coulibaly et al. 2015).

Farmers in north-west Balochistan in Pakistan adopted a variety of coping strategies to mitigate the impacts of drought on their agro-based practices. Among the coping strategies, crop management, adjustment in agriculture inputs, water management, income diversification, asset depletion, expenditure adjustment and migration were important. Crop diversification is one of the well-accepted adaptive strategies used by farmers to diffuse risk.

Apart from this, cultivation of vegetables is gaining momentum, because vegetables are resilient to dry conditions. Farmers point out that the obvious advantages of cultivating vegetables are the short time of cultivation and their market demand. Wheat is another cropthatdepends only on rainwater, and it is harvested in May or June in Pakistan. Moreover, farmers have shifted to mixed cropping or inter-cropping because it provides an opportunity to grow more than one crop in the same field at the same time. Farmers cultivate various alternative vegetables, such as potatoes, onions, ladies fingers, etc., along with apple trees in their farmlands in Southern Malawi. Apart from crop management, adjustments in input use are another important adaptive strategy practised by Pakistani farmers. The majority of the farmers have reduced the amount of fertiliser and pesticide used in their fields. Farmers who practise this strategy indicated that, due to a lack of water and decline in production, they could not use the normal amount of water, as apple trees require more water, which results in low production and small apples, compared to the normal size and weight before the onset of the drought (Coulibaly et al. 2015).

In addition, a decline in the production of manure, which is hard to find during times of drought, was the reason mentioned by the farmers for the decreasing trend in manure use in their fields. Those farmers who increased the amount of manure or used as per need indicated that it was less expensive and gives strength to the trees and, more importantly, it conserves the soil moisture. In contrast to farm-level adjustment, farmers employ different off-farm adaptation practices to cope with a production shortfall, like seeking off-farm income-generating activities like business, wage labour, services, driving, hotel workers, etc. Apart from income diversification, farmers sell their belongings to reduce their vulnerability due to the drought. Many farmers attempted to cope with the drought by selling their livestock, others by selling agriculture tools, household utensils, their agricultural land, and their non-agricultural land. The economisation of expenditure or consumption smoothing is practised by farm households when they experience a temporary decline in income. Many farmers have used this strategy to cope with production and income decline. Farmers have reduced both the number of meals taken per day and the purchase of expensive food items to cope with income loss. In addition, farm households have also minimised expenditure on healthcare, clothing, children’s education, house maintenance, and social events during the drought period (Coulibaly et al., 2015).

Various coping strategies adopted by farmers in Ethiopia are credit services, past savings, sale of labour, sale of assets, sale of livestock and their products, sale of trees and a change in livelihood strategies. The main coping strategies used are the sale of labour and the sale of livestock and their products. The farmers in the rain-fed area do not have any coping strategy and are fully ‘at God’s mercy’. It has been witnessed that farmers (especially young men) from the rain-fed area migrate to the nearby urban centres or irrigation projects during drought seasons to provide labour for their own daily subsistence and send a major part of their income to their families. However, those having livestock depend on the income from the sale of livestock and their products during such critical times in order to avert the impacts of drought. In addition to the coping strategies taken by the farmers themselves, there are various sources of financial and other types of support (government, NGOs, relatives, etc.) for them during the critical times of droughts. However, it can be argued that this strategy would leave the local people in an extreme state of vulnerability by compelling the community to look forward to handouts during times of drought (Desalegn et al. 2006).

Habiba, Shaw, and Taeuchi (2012) illustrated that, inNorth-Western Bangladesh, farmers in both irrigated and non-irrigated villages are adopting a variety of adaptation strategies in their farming practices to deal with drought. Some of the coping strategies include: agronomic management, water harvesting, water resources exploitation, crop intensification, alternative enterprises, other income-generating activities and also selling of livestock, migration and borrowing money from relatives and neighbours (Habiba, Shaw, and Taeuchi 2012).

In the Republic of Benin, crop-livestock diversification (mixed cropping, intercropping and crop rotation) is a common adaptation practice. Farmers use crop-livestock diversification as an adaptation strategy to reduce the adverse effect of climate change on farm productivity. “Crop-livestock diversification and other good practices (mulching, organic fertilizer)”, “Use of improved varieties, chemical fertilizers and pesticides”, “Agro-forestry and perennial plantation (oil palm, orchard, tree species)” and “Diversification of income-generating activities” (Mahouna, Fadina, and Barjolle 2018; 12). Some of the farmers also use mulching and organic fertilisers in addition to crop-livestock diversification. In addition, some farmers have adopted small ruminant and poultry farming to diversify their sources of income. Thelivestock are mainly fed with crop residues. This strategy is for the minimisation of agro-climatic risks because arboriculture is a good bulwark against climate change. Some farmers practise agro-forestry (integrating trees and crops), and these farmers have a deep knowledge of the benefits of such practice: preventing soil erosion, reducing losses of water, increasing the availability of organic matter and nutrients, and reducing the amount of agricultural insect pests and associated diseases (Mahouna, Fadina, and Barjolle 2018).

According to Mertz et al. (2009), in rural Sahel, households make use of a few adaptation measures to counter perceived climate impacts on agricultural production, which include new crops or crop varieties (mostly vegetables); keeping animals in stables; replacing horses with cattle, which are cheaper to feed; and using manure. Credit schemes and support from NGOs are important adaptive measures needed within agriculture in rural Sahel, and a focus on revitalising the traditional solidarity measures, especially for aiding each other with family events and during crises, is emphasised (Mertz et al. 2009).

Moranga (2016) illustrates that, in Kenya, irrigation for production is the most common adaptation measure taken by farmers. Water rationing is very common due to erratic rains that cause low water availability in irrigation schemes. Irrigation water is supplied for farmers' plots at three-week intervals. Planting of trees is used as a measure of coping with climate change, due to their recognition of its economic and ecological benefits. Nair, Kumar, and Nair (2009) viewagro-forestry as a means of enhancing carbon sequestration, thereby mitigating climate change. Diversification of income is also an important adaptation measure taken by the farmers. The majority of the farmers depend on more than one income source to spread risks. For example, some grow a variety of crops and keep livestock. Others engage in off-farm employment activities such as trading and casual labour. Only a few farmers have adopted crop insurance as an adaptation strategy. Some farmers practise mulching. This is attributable to its role in improving soil fertility as a result of decomposition, conserving soil moisture, preventing soil erosion and reducing weeds (Montenegro et al., 2013; Patil, Kelkar, and Bhalerao 2013).

According to Bruin (2011), the adaptation strategies practised in the Netherlands include switching crops, shifting the crop calendar, engaging in new management practices for a specific climate regime, changing irrigation systems and selecting different cropping technologies. Public adaptation involves action taken by the local, regional and/or national government to provide infrastructure and institutions to reduce the negative impact of climate change. Public adaptation strategies include the development of new irrigation infrastructure, transport or storage infrastructure, land-use arrangements and property rights, and watershed management institutions (Swiderska et al.2011). In crop production**,** reactive adaptation strategies include control of soil erosion, construction of irrigation dams, improving soil fertility, development of new varieties, and shifting planting and harvesting time. Anticipatory adaptation strategies, on the other hand, involve the development of tolerant cultivars, research development, policy measures on taxation and incentives (Shongwe, Masuku, and Manyatsi 2014). Bryan et al. (2009) suggest that smallholder farmers can adapt to climate change by changing planting dates and diversifying crops. This can be possible if government provides them with the necessary support. Smallholder farmers can also adapt to climate change by practising soil and water conservation measures and planting trees (Deressa et al. 2009).

Dhaka, Chayal, and Poonia (2010) found in their study that the majority of farmers in Bangladesh were using various adaptation strategies in response to climate change. Of all the adaptation strategies, increased use of irrigation was the most important. Irrigation increases the yield of production, improving nutrient availability to the plants, but also leading to increased soil salinity (Dhaka, Chayal, and Poonia 2010). Practising crop diversification was also identified as an important adaption strategy. Continuous mono-cropping (for example rice cultivation) has different adverse effects, which include pest resurgence and soil quality deterioration, in addition to the issues of loss risk associated with monocultures. In response to these effects, farmers adopt diversified cropping practices, reducing overall farm risk and expanding opportunities for farm profit, which generally act to boost the farmers' average incomes. The third most important adaptation strategy is the "integrated farming system" (being engaged in two or more enterprises which act symbiotically with one another) (Uddin, Bokelmann, and Entsminger 2014; 231). This farming system is becoming more popular throughout the country because of its economic returns (Alam et al. 2009; Mangala 2008; Uddin and Takeya 2005; Ugwumba et al. 2010). Crop insurance was ranked as the least important adaptation strategy (Uddin, Bokelmann, and Entsminger 2014).

There are various drought preparedness measures adopted by farmers in the Maharashtra state of India. Drought mainly affects crop and livestock production, therefore farmers prefer not to sell their crop produce and instead store it to deal with anticipated droughts. Other farmers store crop residues to fulfil the fodder demand during the anticipated drought; while others reduce their expenses and save money. Farmers seek various options, such as migration for employment, selling of livestock and non-agricultural income sources to lessen the drought impacts. A few farmers have irrigation facilities and sow crops on time, despite the irregular monsoon, and even fewer choose crops requiring less water to deal with drought. However, other farmers tend to be well prepared to deal with any anticipated drought by storing harvested grain and saving money compared to those in medium- and highly irrigated areas. Farmers with small landholdings tend to sell their livestock and seek alternative sources of income to cope with drought (Udmale et al. 2014). Major agricultural adaptations include changing the crop calendar, using crops that consume little water, no sowing, using improved irrigation practices, water harvesting and reducing wastage of water during drought (Dhaka, Chayal, and Poonia 2010;Gandure, Walker, and Botha 2013; Habiba, Shaw, and Taeuchi 2012; Roy and Hirway 2007; Sahu and Mishra 2013).

According to Maddison (2006), adaptations are dependent on customs, institutions and policies; one might expect to see differences in the extent of adaptation between countries. Analysing adaptations in Africa reveals that, in all countries apart from Cameroon and South Africa, the planting of different varieties of the same crop is considered to be one of the most important adaptations. Different planting dates are considered an important adaptation in Egypt, Kenya and Senegal. Adopting a shorter growing season is universally practised in Senegal but is elsewhere almost irrelevant. In Egypt, themajority of farmers have moved towards non-farming activities. In Egypt, Kenya and South Africa, farmers have adapted by increasing theuse of irrigation. In Burkina Faso, Kenya and Niger there is an increasing use of water conservation techniques. Soil conservation techniques are increasingly practised in Burkina Faso, Kenya, Senegal and Niger. In Burkina Faso, Niger and Senegal, farmers have adopted increasing use of shading and sheltering techniques. Increased use of weather insurance is almost exclusive to Egypt. Prayer and ritual offerings for rain are made in Senegal and Niger. There are, however, several countries in which some farmers do not show change in agricultural practices. These include Burkina Faso, Cameroon, Ghana, South Africa and Zambia (Maddison 2006).

The options for agronomic adaptation include, for example, adjustments to planting dates, fertilisation rates, irrigation applications, cultivar traits, and the selection of animal species. When autonomous agronomic adaptation is included, crop modelling assessments indicate, with medium to low confidence that climate change will lead to generally positive responses at less than a few degrees Celsius warming and generally negative responses for more than a few degrees Celsius in mid-latitude crop yields. It also indicates that the yields of some crops in tropical locations would generally decrease with even minimal increases in temperature, because such crops are near their maximum temperature tolerance and dryland/rain-fed agriculture predominates (McCarthy et al. 2001).

Enhanced resilience to future periods of drought stress may also be supported by improvements in existing rain-fed farming systems (Rockström 2003), such as water-harvesting systems to supplement irrigation practices in semi-arid farming systems (‘more crop per drop’ strategies). Improved early warning systems and their application may also reduce vulnerability to future risks associated with climate variability and change. Using such climate information, it may be possible to give outlooks with lead times of between two and six months before the onset of an event (Nyanga et al. 2011). Drought-tolerant maize and insect-resistant millet, sorghum and cassava, among other cropsare planted during drought. Wheat grain yield cultivated under current and future climate conditions in Egypt include a number of adaptation measures, such as various technological options that may be required under an irrigated agriculture system (Abou-Hadid 2006). A study in Africa by Kurukulasuriya and Mendelsohn (2006) illustrates that farmers select sorghum and maize-millet in the cooler regions of Africa, maize-beans, maize-groundnut and maize in moderately warm regions, and cowpea, cowpea sorghum and millet-groundnut in hot regions. Furthermore, farmers choose sorghum and millet-groundnut when conditions are dry, cowpea, cowpea-sorghum, maize-millet and maize when medium-wet, and maize-beans and maize-groundnut when very wet. As the weather becomes warmer, farmers tend to shift towards more heat-tolerant crops. Depending on whether precipitation increases or decreases, farmers will shift towards water-loving or drought-tolerant crops respectively (Boko et al. 2008).

The adaptation strategies and coping mechanisms adopted by farmers in sub-Saharan Africa include: switching from planting high water-requirement to low water-requirement crops (Deressa et al. 2009; Gandure, Walker, and Botha 2013; Hassan and Nhemachena, 2008), while crop farmers where flooding is frequent plant short-duration crops and have changed the planting and harvesting times to avoid crop growing and harvesting during the intensive rainfall period (Acquah-de Graft 2011; Acquah-de Graft and Onumah 2011; Fosu-Mensah, Vlek, and Manschadi 2010). Usually, farmers have switched to planting diversified crops, changed planting dates to correspond to the change in the precipitation pattern, planting tree crops, mixed cropping and off-farm income-generating activities (Juana, Kahaka, and Okurur 2013). Farmers in southern Africa and parts of East Africa, where most countries are water stressed, have developed water conservation methods such as water harvesting, waste water re-use in agriculture and crop irrigation (Deressa et al. 2008; Gandure, Walker, and Botha 2012; Gbetibuou 2009; Mengistu 2009; Mertz et al. 2009; Nyanga et al. 2011; Yesuf et al. 2008), while farmers in West Africa, where most countries experience a short, intensive rainy season, plant short-duration crops, and practise upland farming (as opposed to swamp farming) and soil conservation methods (Acquah-de Graft 2011; Apata, Samuel, and Adeola 2009; De Wit 2006; Kurukulasuriya and Mendelson 2006; Sofoluwe, Tijani and Baruwa 2011).

2.4.3 South African research on adaptation/coping strategies used by farmers

Olaleye (2010) illustrated that coping mechanisms adopted by farmers in the Free State Province, South Africa during periods of drought include gardening and selling vegetables, working as casual labourers, selling livestock and livestock products, such as milk, and little use of credit; unlike in other countries of the world, except in rare cases, the sale of personal effects (such as jewellery or watches), household effects (such as furniture) or items of agricultural equipment to raise cash during drought emergencies does not occur among certain farmers. Olaleye (2010) describes the three most important adjustment mechanisms as the sale of livestock, the use of financial assets and additional employment (Olaleye 2010).

According to Ngaka (2012), farmers in the Eastern Cape and Free State provinces of South Africa are willing to pay for livestock feed in order to maintain a nucleus herd of cattle. The majority of farmers indicated that they had sold their livestock as a measure to cope with the devastating drought conditions. The selling of livestock tends to be a drastic measure for the emerging small- and medium-scale farmers respectively as a measure to alleviate the impact of a drought disaster. Other coping strategies include movement of livestock to better grazing camps, purchase of remedies, particularly vitamin A supplements, fetching water for livestock, and weaning calves earlier than usual (Ngaka 2012).

According to Mdungela, Bahta, and Jordaan (2017) farmers in the OR Tambo District in the Eastern Cape province of South Africa employ cultivars or breeds that are less sensitive to drought. Cacadu district farmers use more irrigation. Afew farmers employ diversification in their farming activities, which leaves most of the farmers vulnerable. Nevertheless, farmers who practise diversification on their farms are more resilient during drought. To manage drought effectively, diversifying livelihood strategies and income-generating options within and outside agriculture are required, especially through non-farm enterprises and employment opportunities. Farmers also plant food gardens to support their families, and others keep chickens. Communal farmers sell their excess animals and non-farming assets to buy feed for their livestock. Other farmers plant oats to make silage and lucerne for grazing that can be used in dry periods. Changing the type of livestock and crops and reducing herd sizes arealso used as an adaptation strategy (Mdungela, Bahta, and Jordaan 2017).

According to Benhin (2006), farmers across South Africa identified a number of adaptation options they make use of to address the changes they perceive in the climatic conditions. The main adjustments in farming activities are: adjustments in farming operations, including changes in the planting dates of some crops, planting crops with a shorter growing period, such as cabbage, and planting short-season maize. Others include the increased use of crop rotation and the early harvesting of some crops. In KwaZulu-Natal, for example, farmers cut their sugarcane at an early stage to avoid loss of production due to the dryness of the cane (as a result of increased temperature) if they wait for the cane to mature in the field. Farmers who are affected resort to delaying the start of the planting period, increased use of modern machinery to take advantage of the shorter planting period, collection of rain water by making furrows near the plants, and increased use of irrigation. When there are high temperatures, farmers have resorted to using heat-tolerant crop varieties, crop varieties with high water-use efficiency, early maturing crop varieties, and increased crop and livestock farming (mixed farming) (Benhin 2006).

Another practice is to change the timing, duration and location of grazing. Increase in temperature and higher evaporation caused farmers to increase chemical application in order to slow down evapotranspiration. In addition, farmers apply more farm manure to keep the moisture content of the soil higher and retain the soil's fertility. There is an increased use of irrigation; with water being the most important factor limiting agriculture in South Africa,irrigation appears to be the most used adaptive strategy. Farmers have also shifted from flood irrigation to sprinkler irrigation for efficient use of the limited water. Several farms have also built their own boreholes to make effective use of underground water. There has also been increased use of wetlands for agricultural production. When it is hot, livestock farmers plant trees to provide natural shade for their livestock or as a wind or hail storm break. In response to the increased occurrence of droughts, farmers have adopted various soil conservation practices in order to maintain or improve soil moisture and fertility (Benhin 2006).

Furthermore, farmers have built many small dams or planted trees around their farms. Farmers have also increased their fallow periods by as much as one to two agricultural seasons (instead of continuous cropping) to allow the land to restore its nutrients. Another conservation technique farmers use to protect the soil against erosion is to keep the crop residues of the previous harvest on the land. To preserve soil moisture, cool the soil surface and stabilise soil temperature, they use mulching (layers of muck, peat, compost and plastic) to cover the land. To avoid excessive extraction of nutrients from the soil of their farms, farmers have also reduced the density of crops or livestock on their land. They have also reduced the risk of losing income when farm produce decreases as a result of the increased variability in the climate, some (especially large-scale farmers) have insured their farms, while others (especially small-scale farmers) are increasing their involvement in non-farm activities. Most large-scale farmers have also opted to taking lower risks by reducing their cropping areas to manageable sizes (Benhin 2006).

Ndhleve, Nakim, and Longo-Mbenza (2017) found that the farmers in the Eastern Cape province of South Africa practise irrigation and change of planting date as adaptation practices. Farmers noted that rescheduling the planting date from the traditional planting times to planting dates assisted by the use of weather reports and forecasting curbs the impact of delays in or slow onset of rainfall. Reduction of farming on steep slopes or erosion-prone areas as an appropriate adaptation response was rankedlow, probably because of limited choice with regard to the location of their fields. Farmers are seemingly more reactive to shocks and adaptive responses that are not capital intensive.

Table 2.1: Farmers' adaptation measures across the world.

Coping strategies		References
Drought/low flow protection		
1	Technical measures to increase supply (e.g. reservoir volumes, water transfers, desalinisation)	Mutekwa (2009)
2	Increasing efficiency of water use (e.g. leakage reduction, more efficient irrigation)	Habiba, Shaw, and Taeuchi(2012)
3	Economic instruments/External costs(e.g. water pricing)	Apata, Samuel, and Adeola (2009); Hermann (2009)
4	Restriction of water use	Habiba, Shaw, and Taeuchi et al., (2012)
5	Improving forecasting, monitoring, information	Githeko (2007)
6	Improving insurance schemes against drought damage	Benhin (2006)
General adaptation measures		
1	Policy – including new/revised legislation, bills, Acts of Parliament, etc.	Benhin (2006)
2	Economic incentives and financial mechanisms	Desalegn et al. (2007);Olayeye (2010)
3	Awareness-raising or information campaigns	Mdungela, Bahta, and Jordaan (2017)

2.5 Empirical literature of factors influencing smallholder farmers' choice of adaptation

Factors influencing smallholder farmers' choice of adaptation strategies have received some attention in the recent literature. Previous studies on adaptation to climate change have identified its major determinants, including different household and farm characteristics, infrastructure, and institutional factors (Obayelu, Adepoju, and Idowu 2014).

Gender

Ogunniyi (2011) found that male-headed households are more likely to adopt drought-tolerant varieties and less likely to grow new crops and use new land management practices. The possible reason for that is that much of the farming activities are done by males, while females are more involved in the processing, and this will give males an edge in terms of farming experience and information on various management practices and what needs to be done in response to climatic instability. Studies by Bryan et al. (2009), Mandleni and Anim (2007)and also foundthat male-headed households adapt more readily to climate change. According to Asfaw and Admassie (2004), male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households. Moreover, Tenge, De Graaff, and Hella (2004) argue that having a female-headed household may have negative effects on the adoption of soil and water conservation measures, because women may have limited access to information, land and other resources due to traditional social barriers. A study by Hassan and Nhemachena (2008)found contrasting results, arguing that female-headed households are more likely to adapt because they are responsible for most of the agricultural work in the region and therefore have greater experience and access to information on various management and farming practices. A similar result was reported by Shongwe, Masuku, and Manyatsi (2014), who found that female-headed households are more likely to take up adaptation options, since most of rural farming is done by women, while men are employed in towns, cities and on mines. The effect of gender of the household head on the choice of adaptation strategy is either positive or negative.

Educational level

A higher level of education is believed to be associated with access to information on improved technologies and higher productivity (Deressa et al. 2009). Evidence from various sources indicates that there is a positive relationship between the levels of education of the household head and adaptation to climate change (Igoden, Ohoji, and Ekpare 1990; Lin 1991; Maddison 2006). Education significantly increases the probability of adapting to climate change (Deressa et al. 2009; Ogunniyi 2011). An increase in number of years of schooling increases the probability of adaptation to climate change (Deressa et al. 2009). Therefore, farmers with higher levels of education are more likely to adapt better to climate change (Asfaw and Admassie 2004). A similar result was reported by Clay, Reardon, and

Kangasniemi (1998), who found that almost all values of education are positive across all adaptation options. This indicates a positive relationship between education and adaptation to climate change.

Household size

The influence of household size on the choice of adaptation strategy can be seen from two angles. The first assumption is that households with large families may be forced to divert part of the labour force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family (Yirga 2007). The other assumption is that large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks. For instance, Croppenstedt, Demeke, and Meschi (2003) argue that households with a larger pool of labour are more likely to adopt agricultural technology and use it more intensively because they have fewer labour shortages at peak times. It is expected that households with large families are more likely to adapt to climate change. Although there was a positive sign for most adaptation methods, increasing household size did not significantly increase the probability of adaptation. There can an indirect relationship that the larger the size of the household, the better the chance of adapting to climate change. According to Ogunniyi (2011), for most of the adaptation methods, increasing household size does not increase the probability of adaptation. This implies that large families are able to adopt drought-tolerant crop varieties, whereas smaller ones do not adapt to climate change. The empirical adoption literature shows that household size has mixed impacts on farmers' adoption of agricultural technologies. Larger family size is expected to enable farmers to take up labour-intensive adaptation measures (Anley, Bogale, and Haile-Gabriel 2007; Birungi 2007; Dolisca et al. 2006; Nyangena 2007). Then again, a large family might be forced to divert part of its labour force into non-farm activities to generate more income and reduce consumption demands (Tizale 2007). This indicates a positive or negative relationship between household size and adaptation.

Household Income

Alam (2015) found in a study conducted in Bangladesh that an increase in household income raises the probability of the farmers' adoption strategy. For example, a unit increase in household income increases the probability of adaptation of a coping strategy, although not to a greater extent (Alam 2015).The farm income of the households surveyed has a positive impact on conserving soil, using different crop varieties, and changing planting dates. A unit increase in farm income increases the probability of adapting. When the main source of income is farming and the amount of land for farming is limited, farmers tend to invest in productivity smoothening (Deressa et al. 2009). According to Bryan et al. (2009), Demeke and Zeller (2012), Deressa et al. (2011) and Semenza et al. (2008), a higher income level increases the probability of drought perception. However, this is in contrast with the findings of Legesse and Drake (2007), who reported that farmers with increased wealth and assets in the eastern highlands of Ethiopia were less perceptive of drought risk. The fact that economically active members in the household increases the likelihood of coping is probably because higher labour endowment would enable a household to engage in various agricultural and non-agricultural tasks, especially during stress periods. Farm and nonfarm income represent wealth. It is regularly hypothesised that the adoption of agricultural technologies requires sufficient financial wellbeing (Knowler and Bradshaw 2007). Other studies that have investigated the impact of income on adoption found a positive correlation (Franzel 1999). Higher income farmers may be less risk averse and have more access to information, a lower discount rate, and a longer term planning horizon, which are expected to have a positive influence on farmers' choice of adaptation strategies (CIMMYT 1993).

Off/non-farm income

Tezeze et al. (2012) found off/non-farm income to be positively related to improved crop varieties, soil and water conservation techniques, adjusting planting date and crop diversification. Non/off-farm income increases the likelihood of improved crop varieties, adjusting planting date and crop diversification. But off/non-farm income decreases the probability of the adoption of soil and water conservation techniques. This indicates that, when farmers have options for non/off-farm incomes, they can afford the cost by using less of agronomic practices such as soil and water conservation (Tazeze et al. 2012).

Age

The age of the household head, used as a proxy for farming experience, positively affected the propensity of detecting changes in climate variability and extremes. Previous works byIshaya and Abaje (2008), Maddison (2006), and Tazeze et al. (2012) arrived at a similar conclusion. On the other hand, elderly people do not have a better ability to convert their perception into taking coping action, suggesting that risk awareness alone is not sufficient for making coping decisions. Given the risk-averse behaviour of aged farmers, older age may mean less coping. In a study conducted in the highlands of Ethiopia, Deressa et al. (2009) found that the older the age of the household heads, the less likely they were to adapt. Some studies found that age had no influence on a farmer's decision to participate in forest and soil and water management activities (Anim 1999; Bekele and Drake 2003; Thacher, Lee, and Schelhas 1997; Zhang and Flick 2001). Others, however, found that age is negatively related to farmers' decisions to adapt (Anley, Bogale, and Haile-Gabriel2007; Burton, Rigby, and Young 1999; Dolisca et al. 2006; Featherstone and Goodwin 1993; Gould, Saupe, and Klemme 1989; Lapar and Pandely 1999; Nyangena 2007). However, Bayard et al. (2007), Ndambiri et al. (2014) and Okeye (1998) found that age is positively related to the adoption of conservation measures. There is an assumption that old age is associated with more experience and older farmers therefore can be expectedto adapt to changes in climate.

However, younger farmers are expected to have a longer planning horizon and to take up long-term adaptation measures, such as irrigation and mixed crop-livestock systems (Hassan and Nhemachena 2008). A study by Ogunniyi (2011) found that age of the household head affected adaptation to climate change. The finding followed the intuitive position, as it is expected that the household head's age will be closely related to experience of how climate changes overtime. However, the majority of the farmers belong tothe non-active age group, but have experience in farming. Old age has a negative relationship with adopting climate change and drought adaptation strategies, as agriculture is labour intensive, hence it requires healthy individuals (Shongwe, Masuku, and Manyatsi 2014).

Marital status

According to Mandleni and Anim (2007), married farmers are more aware of and adapted to climate change. The possible reason is that these farmers have families who stayed with them for a reasonable amount of time to observe climate change. The marital status of the farmer implies that most farmers have land property rights, as found in the study by Shongwe, Masuku, and Manyatsi (2014).

Farming experience

Age of the head of household can be used to capture farming experience. A study in Ethiopia has shown a positive relationship between number of years of experience in agriculture and the adoption of improved agricultural technologies (Kebede, Gunjal, and Coffin 1990), while a study by Shiferaw and Holden (1998) indicates a negative relationship between age and the adoption of improved soil conservation practices. On the other hand, studies by Maddison (2006) and Hassan and Nhemachena (2008) indicate that experience in farming increases the probability of uptake of adaptation measures to climate change. Studies show that the greater the experience in agricultural farming, the more likely farmers are to have good knowledge about the weather and climatic conditions, and thus adapt to these risk factors. Hisali, Birungi, and Buyinza (2011) point to the importance of farming experience in adaptation decision making. Farming experience has varying effects on different adaptation measures. For instance, a one-unit increase in farm experience results in a higher likelihood of adapting by crop diversification (Alam 2015).

Farming experience will positively influence farmers' decisions to take up adaptation measures. This indicates that farming experience positively affects the choice of adaption. The household head is more experienced and is expected to acquire more competence in weather forecasting. This helps to increase the likelihood of practising different adaptation strategies to climate change (Mahouna, Fadina, and Barjolle 2018). The more experienced farmers are more likely to adapt to drought-tolerant crop varieties than the less experienced ones. A unit increase in the years of experience would result in an increase in the probability of adopting drought-tolerant crop varieties (Ogunniyi 2011). General farming experience is not relevant for the empirical model, since most farmers judge their total experience as starting from the first day that they started going out to the mangrove rice fields with their parents. What is important is the experience since the farmer became a decision maker about his own field (Mueller and Jansen 1988).

Farm size

Larger farm sizes reduce the probability of growing new crops but increases the probability of adopting drought-tolerant crop varieties and moving the focus from crop to livestock production (Ogunniyi 2011). Farm size has been shown to positively affect adoption decisions (Norris and Batie 1987; Pham Thi and Chaovanapoonphol 2014; Polson and Spencer 1991). Farm size has a positive impact on multiple coping strategies. The larger the farm, the more farmers opted for the combination of several coping strategies: agroforestry and perennial plantation, crop–livestock diversification, improved varieties, etc. Farm size determines the decision to combine multiple strategies to cope with climate change. This is confirmed by Sani and Chalchisa (2016), who reported that large-scale farmers are more likely to adapt to climate change because they have more capital and resources (Mahouna and Nhemachena 2018). Empirical adoption studies have found mixed effects of farm size on adoption. For example, a study on soil conservation measures in South Africa showed that farm size was not a significant adoption factor (Anim 1999). On the other hand, Nyangena (2007) found that farmers with a small area of land were more likely to invest in soil conservation than those with a large area. Hassan and Nhemachena (2008) hypothesise that farmers with large farms would adopt measures that require a large area of land, such as livestock systems, while farmers with small farms are expected to diversify their options (Hassan and Nhemachena 2008).

Seasonal farming

A warmer winter/spring promotes switching to the use of irrigation, multiple cropping, and mixing crop and livestock activities, especially under irrigation. Warming in summer/autumn also tends to be associated with shifting away from mono-cropping. While it is clear that irrigation is the strongest adaptation measure against warming for all systems, mixing livestock with crop cultivation seems to work only with multiple cropping under dryland conditions (Hassan and Nhemachena 2008).

Farmers' awareness of climate change

Awareness of the problem and potential benefits of taking action is another important determinant of the adoption of agricultural technologies. Maddison (2006) found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making. Several studies have found that farmers' awareness and perceptions of soil erosion problems positively affects their decisions to adopt soil conservation measures (Anim, 1999; Araya and Adjaye 2001; Gould, Saupe, and Klemme 1989; Traoré, Landry, and Amara 1998). It is expected that farmers who notice and are aware of changes in climate would take up adaptation measures that help them reduce losses or take advantage of the opportunities associated with these changes (Hassan and Nhemachena 2008).

Access to assets/capital

Access to farm assets: Better access to other farm assets, such as heavy machinery,is found to promote the use of irrigation and the mixing of livestock with cropping activities. This suggests that capital, land and labour serve as important factors for coping with and adapting to climate change. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources) at the disposal of farming households (Hassan and Nhemachena 2008).

Access to electricity: This often represents households' wealth, which influences farmers' adaptation decisions (Bryan et al. 2013). The rural economy and livelihoods are rapidly transforming due to massive electrification being undertaken/implemented. There is a positive relationship between farmers' access to electricity for irrigation and the likelihood of adapting increased use of surface water irrigation to cope with water scarcity. The marginal effects indicate that, compared to the base case, the likelihood of adopting crop diversification and land-use change increases with greater access to electricity. The positive effect of electricity on adaptation is consistent with other studies in developing countries (Hassan and Nhemachena 2008; Kurukulasuriya and Mendelsohn 2008).

Access to credit: Farmers who have access to credit have more chances or money to invest in the high adaptation option (PhamThi and Chaovanapoonphol 2014). Several studies have shown that access to credit is an important determinant enhancing the adoption of various technologies (Anderson and Thampallai 1990; Hassan and Nhemachena 1998; Kandlinkar and Risbey 2000; Tizale 2007; Yirga et al. 1996). With more financial and other resources at their disposal, farmers are able to make use of all their available information to change their management practices in response to changing climatic and other conditions. For instance, with financial resources and access to markets, farmers are able to buy new crop varieties, new irrigation technologies and other important inputs they may need to change their practices to suit the forecasted climate changes. Although access to credit is associated with a positive effect on adaptation behaviour (Gbetibouo 2009), it was found to also be inversely related to farmers' adaptation to changes in climate such that farmers with access to credit were less likely to adapt to climate change compared to farmers without access to credit (Ndambiri et al. 2014). The possible reason for this is that the adoption of an agricultural technology may demand the use of owned or borrowed funds. Since such an investment in technology adoption may be hampered by a lack of borrowing capacity, this may negatively end up affecting any adaptation efforts by the farmers. Financial constraint is a disincentive to putting more land under cultivation and acquiring farm inputs. Receiving informal credit from friends and relatives helps complement a farmers' own savings in order to overcome cash constraints that are critical to production and productivity. Terms and conditions on borrowing from friends and family are normally less stringent (in terms of collateral, period of repayment, interest rate, among others) than borrowing from formal institutions, thereby making it a more convenient and comfortable system for smallholder farmers. Borrowing from friends and family is usually based on trust and the financial capacity of the lender, and not necessarily on the amount requested.

Access to agricultural services: Extension services are an important source of information on agricultural practices, as well as on climate. Extension education is an important factor motivating the increased intensity of use of specific soil and water conservation practices (Anderson and Thampallai 1990; Baidu-Forson 1999; Bekele and Drake 2003; Pereira de Herreraand Sain 1999; Tizale 2007; Traoré, Landry, and Amara 1998). In Haiti, farmers with better access to extension services were more likely to adopt improved technologies (Anley,Bogale, and Haile-Gabriel 2007). Other adoption studies, however, have found that extension was not a significant factor affecting the adoption of soil conservation measures (Birungi 2007; Nkonya et al. 2005; Pender et al. 2004).

Access to institutional facilities: Households with better access to institutional facilities are generally more likely to adapt to climate change. For example, households with high access to various institutional facilities are more likely to adopt crop diversification as a coping strategy. However, moderate institutional access increases the probability of adopting crop diversification and reduces the probability of the increased use of surface water. This finding is similar to other research that finds a strong positive relationship between access to institutions and the farmers' adoption behaviour (Maddison 2006).

Access to climate information: Farmers who have access to climate information or have more information have a higher probability of high adaptation (PhamThi and Chaovanapoonphol 2014). The availability of information is positively related to adoption (Ndambiri et al. 2014; Pereira de Herrera and Sain 1999). This finding links to the fact that extension agents focus on promoting conservation tillage, thus a lack of information did not limit adaptation (Pereira de Herrera and Sain 1999). Although access to information about climate change positively affects adaptation, it does not have a significant effect on awareness. It shows that the media play an important role in informing livestock farmers about climate change, as this has increased the tendency of adapting to climate change (Kandlinkar and Risbey 2000). Changes in temperatures have a negative effect on awareness of climate change and adaptation thereto (Mandleni and Anim 2011). The availability of better climate and agricultural information helps farmers make comparative decisions among alternative crop management practices and hence choose the ones that enable them to cope better with changes in climate (Baethgen, Meinke, and Gimene 2003; Jones 2003; Kandlinkar and Risbey 2000).

Hassan and Nhemachena (2008) noted that the availability of improved climate and agricultural information helps farmers make comparative decisions for alternative strategies. Some of the variables in the institutional index are pertinent for enhancing financial, social and human capital. For instance, access to credit increases the financial resources of farm households and the ability to purchase inputs such as drought-tolerant varieties and irrigation. Similarly, access to markets (selling or purchasing) serves as a platform for exchanging information (GideyGebrehiwot, Gidey, and Van der Veen 2013). Agricultural extension services – farmer-to-farmer or provided by government and/or non-government organisations – are vital sources of information on agronomic practices and climate change adaptation strategies. Access to information on climate change is believed to create awareness and increase the probability of adaptation (Maddison 2007).

Farmers who have more information and training from extension service programmes have a higher probability of choosing an adaptation strategy (PhamThi and Chaovanapoonphol 2014)

2.6 Chapter summary

The literature discussion reveals the relationship between the types and duration of drought inthe households and community. It reveals the impact that drought has on farmers and their vulnerability to drought impacts. In most cases, drought leaves households devastated economically, environmentally and socially, with an impact on food security, farming income, and food prices. The discussion illustrates that there are two types of droughts that are categorised into four categories. Drought impacts make farmers vulnerable. There are different types of vulnerability that affect farmers. The discussion further explains how the 2015/2016 drought affected farmers in South Africa, especially those in the Free State province.

Perception is important in analysing adaptation decisions. It is important to know the farmers' perception because, in order for them to adopt a certain adaptation strategy, they must have some sort of knowledge. How farmers perceive drought and climate change in South Africa differs from how farmers perceive them in other countries, due to farmers' personal experiences and their level of knowledge. The discussion further explains factors that influence farmers' perceptions and how perception as a factor influences farmers' choice of coping/adaptation strategies. These factors include gender, education level, household size, household income, off/non-farm income, age, marital status, farming experience, farm size, access to electricity, access to climate information, access to credit, farmers' awareness of climate change and seasonal farming. Different types of adaptation and coping strategies to climate change were discussed, highlighting the international and local adaptation/coping strategies used by farmers. The coping strategies include livelihood diversification, migration, remittances, soil and water conservation strategies, growing legumes, fertilisers, changing planting decisions, changing livestock feed, increasing cultivated land, water management, crop management, mixed cropping, income diversification, livestock sales, sale of assets, water harvesting and livelihood systems.

Furthermore, in South Africa, farmers are found to be vulnerable to drought. Occurrences of drought increase farmers' vulnerability by exposing them to poverty and lack of access to resources, unemployment, credit risk and inequality. The sustainable livelihoods framework explains how livelihood assets (capitals) are used to analyse how farmers make an effort to convert their strengths into positive livelihood outcomes. The sustainable livelihood framework (SLF) was discussed to detail farmers' livelihoods and adaptation in a context of vulnerability to climate change.

The review of the literature shows that the factors influencing smallholder farmers' choice of adaptation/coping strategies include personal factors, gender, educational level, household size, income, off/non-farm income, age, marriage and farming experience. Physical factors such as farm size and access to electricity were found to influence farmers' choice of adaptation/coping strategies, as did different asset or capitals. Therefore, all factors were hypothesised to influence smallholder farmers' choice of adaptation/coping strategies.

CHAPTER 3: DATA AND METHODOLOGY

This chapter is presented in four sections. The first section presentsthe description of the study area, while second section focuses on data collection, how the questionnaire was developed and administered and the sampling approach of the study. Third sectionpresents the characteristics of the respondents considered in the study. Fourth section describes the procedures employed in analysing the precise objectives of the study and the last section presents the chapter summary.

3.1 Study area

3.1.1 Thaba ‘Nchu in the Mangaung District of the Free State

Mangaung covers 9 887 km² and comprises of prominent urban centres, which are surrounded by an extensive rural area. It is centrally located in the Free State. As far as the population distribution is concerned, more than half of the population is concentrated in the Bloemfontein area (52%), followed by Botshabelo (28%) and other areas (20%) (Mangaung Metropolitan Municipality Draft Integrated Development Plan 2017). Mangaung has a population of 747 431, of which 83,3% are black African, 11,0% are white, 5,0% are coloured, with other population groups making up the remaining 0,7% (Statistics South Africa [Stats SA] 2011). Figure 3.1 shows a map of the Free State province, indicating the physical location of Mangaung District and the other districts.

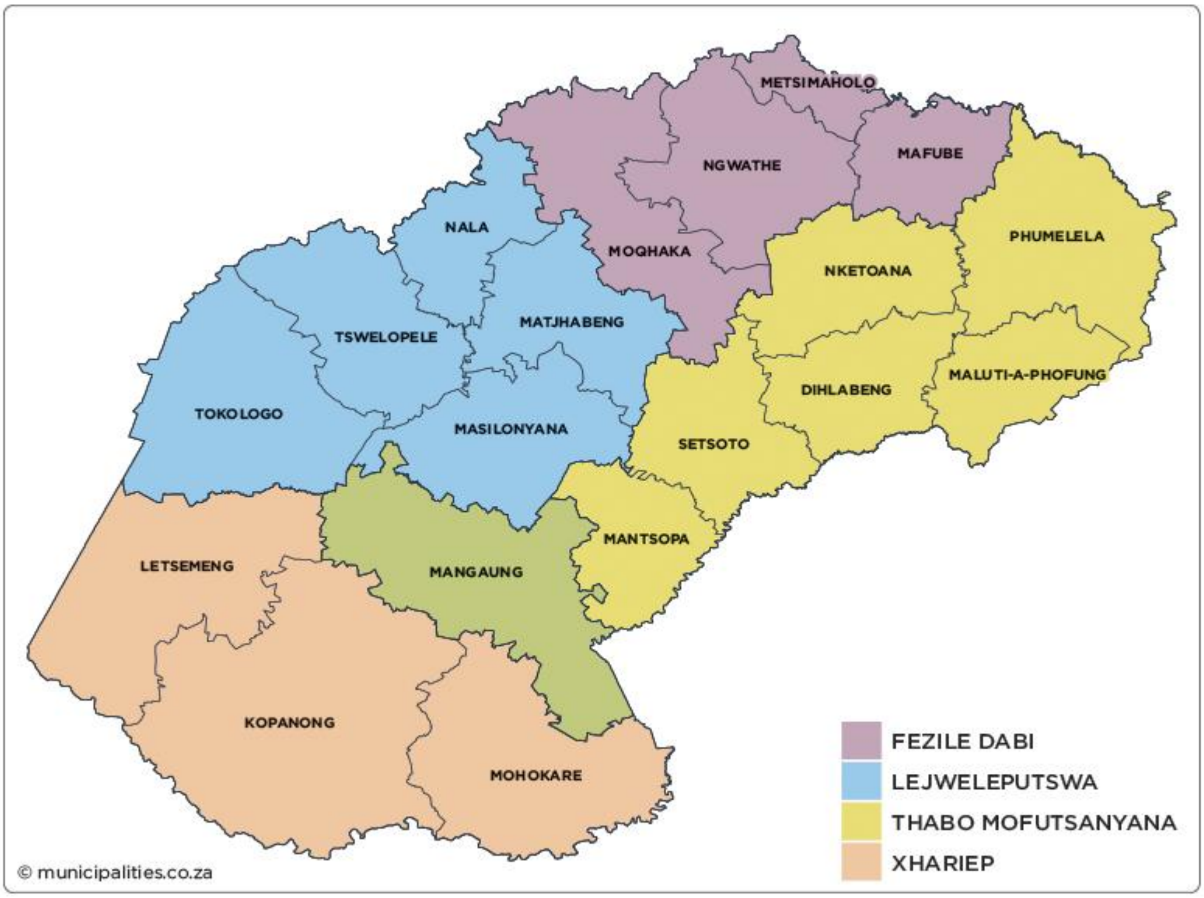

Figure 3.1: Free State District Municipalities Map

Source: municipalities.co.za (2018)

Mangaung is the largest contributor to the GDP of the Free State province and is regarded as one of the most diverse economies. In 2014, the Free State province had a total GDP of R190 billion in current prices. The largest contribution came from the MangaungMetropolitan Municipality (MMM) (Mangaung Metropolitan Municipality Draft Integrated Development Plan 2017).

Thaba ‘Nchu is located 67 km east of Bloemfontein and has a more scattered development pattern, with 37 villages surrounding the urban centre, some as far as 35 kilometres from the urban centre and 12km further to the east of Botshabelo which used to be part of the Bophuthatswana “Bantustan”. The population is largely made up of Tswana and Sotho people. The town was settled in the 1830s and officially established in 1873. The town grew larger following the 1913 Natives’ Land Act, which set aside Thaba‘Nchu as a land for Tswana people. It was known among the Voortrekkers as Blesberg (bald mountain).As a result of its settlement history, it exhibits a large area of rural settlements on former trust lands. The area is characterised by vast stretches of communal grazing areas that surround the urban centre. Many residents still keep cattle within the urban area, and this creates a problem for residents. The majority of new urban developments have taken place towards the west, along Station Road, while the central business district has developed to the east of these extensions. Again, this leads to some urban communities in the urban core to be as far as eight kilometres from the economic opportunities. Thaba 'Nchu has always been a major service centre to the Eastern Free State with many government departments establishing regional offices in this area. However, recently many of these offices and amenities have closed down, thus leaving the town crippled in terms of economic investment (Mangaung Metropolitan Municipality Draft Integrated Development Plan 2017).

The Free State agricultural sector, just like the national agricultural sector, comprises crop production, animal production, horticulture, dairy farming, game farming, aquaculture, fruit production and agro-processing. Approximately 14.5% of South Africa's commercial farming takes place in the province. This sector is critical to the well-being of the province, both as the provider of food and a major employer. Major crops are maize, soy beans, wheat, sorghum, sunflowers, potatoes, groundnuts and wool. The province also accounts for 90% of cherry production in South Africa (Free State Development Corporation 2011). The Free State province is one of the main producers of grain in South Africa. More than 50% of sorghum, almost 50% of sunflower and more than 30% of all wheat, maize, potatoes and groundnuts in South Africa are produced in the fertile western plains and in the northern Free State (Maphalla and Salman 2002). According to Stats SA (2011, the number of agricultural households with the specific types of activities in Thaba 'Nchu are livestock production (8063), poultry production (8605), vegetable production (23591), production of other crops (19929) and other (6699).

Figure 3.2: Location of the study area

Source: municipalities.co.za (2018).

3.1.2 Climate in Thaba 'Nchu

The Free State province has a continental climate, with very warm to hot summers and cool to cold winters. Some areas in the east of the province often experience snowfalls, especially on the higher ranges, whilst it can be extremely hot in the west during summer. The climate of the Free State allows a thriving agricultural industry (Nyam 2017). Its vast beauty endures a fair amount of hardship due to its hot, arid climate. Almost uniformly at about 1300m above sea level, the Free State has weather typical of an interior plateau, with summer rains, chilly winters and plenty of sunshine. The province experiences an annual rainfall of between 600mm and 750mm in the east; this declines slowly to 250mm in the south-western parts of the province. The winters are sometimes very cold, with heavy frost over most of the province. The average winter temperatures range between 12.5°C and 15.0°C in the eastern parts of the province, and increase to an average range of 17.5°C to

20°C in the west during the summer (Nyam 2017). January is the warmest month of the year, with an average temperature of 21.5°C in Thaba ‘Nchu, while June is the coldest month, with 6.9°C on average. The average annual rainfall of Thaba ‘Nchu is 629mm. The average annual temperature of Thaba ‘Nchu is 15.2°C, which is higher than that of other districts, which have an average annual temperature of 14.8°C (Climate-Data 2017).

3.2 Data collection

3.2.1 Development of questionnaire

The questionnaire was developed to obtain relevant information on the farmers’ personal characteristics, perceptions of drought, vulnerability capitals, and the factors that influence the farmers’ choice of adaptation strategies in Thaba ‘Nchu. According to Hopkins and Antes (1990), a questionnaire is frequently usedas an observational piece of equipment to collect personal data and people’s opinions. It deals with collecting personal information from subjects that may not readily be obtainable using other methods. According to Krathwohl (1993), questionnaires provide structured responses and therefore must be carefully developed and revised to obtain valid data. According to Maraj (2000) the questionnaire has certain advantages that must be considered carefully when choosing it as a research instrument. The advantages include cost considerations, i.e. the questionnaires could be hand delivered to respondents and collected instead of spending money on postage, they produce quick results, when it is not difficult to contact respondents it is a convenient method of data collection, there is a good assurance of anonymity, the questionnaire is ideal for a stable, consistent and uniform measure without variation, and it can cover a wider range of issues (Maraj 2000).

According to Cox (1996), there are certain guidelines that must be consideredwhen constructing a questionnaire. These include avoiding the use of uncommon terms or language use, using simple sentence structure, avoiding words or phrases with unclear or uncertain meaning, avoiding asking respondents’ opinions on a subject they cannot be expected to know anything about, also avoiding writing compound question or phrases. The questionnaire for this study was developed and was then taken to the extension officers to be tested before it was used on a larger scale. During the pilot sampling, it was revealed that some farmers were not comfortable answering certain questions, and also there were questions that were not relevant for farmers in the specific study area. Such questions were either reframed or totally removed from the questionnaire to make it more fitting for the farmers in Thaba ‘Nchu.

The questionnaire was developedso that it was confidential and the questions were not offensive to the farmers. The questionnaire included different types of questions, such as Likert-type scale questions where the farmers had to rate the importance of the specific question asked, ranking questions, where farmers had to rank a set of options by numbering them in order from 1 to the maximum number according to each, and a combination of open-ended and closed-ended questions.

Permission to collect data was granted by the extension officers of the Thaba ‘Nchu Department of Agriculture. Data was collected through face-to-face interviews with the farmers, during which 301 questionnaires were administered in the study area. A comprehensive and structured questionnaire written in English was used as a research tool to collect data. The questionnaire consisted of sections A, B, C, D, E and F. Section A was for identification information, such as the region and village name, the date of the interview, and the name of the respondent. Section B looked at basic information, while section C covered the farmers’ perceptions of drought. Section D looked at drought vulnerability, section E covered adaptation and coping mechanisms, and section F covered the vulnerability indicators.

3.2.2 Sampling procedure and conduct

According to Brynard and Hanekom (2006), sampling is a method used by a researcher to select a small group of people from a larger population with the same characteristics and fitting in-depth information about the proposed study. Sampling methods help to choose individuals who will represent the larger group. The survey employed proportionate stratified random sampling in Thaba ‘Nchu. A complete list of all villages in Thaba ‘Nchu was requested and obtained from the Department of Agriculture. Thaba ‘Nchu is divided into three areas – Central, Northern and Southern Thaba ‘Nchu. Central Thaba ‘Nchu contains 12 villages, while Northern and Southern Thaba ‘Nchu consists of 21 and 12 villages respectively. In Northern Thaba ‘Nchu, the largest area in Thaba ‘Nchu, 14 villages were chosen. Northern Thaba ‘Nchu was chosen as a representative of the study area because it has a lot of farmers compared to the other areas.A total of 14 villages were visited and, in those villages, a specific number of farmers were interviewed. The table below lists the number of respondents in all 14 villages. A total of 301 farmers from different villages in Thaba ‘Nchu were interviewed for this study.

Table 3.1: Number of respondents per village

Villages	No. of respondents per village
Morago	24
Seroalo	21
Woodbridge 2	40
Rakhoi	24
Kommisdrift	16
Motlatla	36
Rooifontein	24
Tabale	13
Mariasdaal	17
Feloane Trust	22
Potsane	14
Moroto	27
Ratabane	11
Tiger River	12

Source: Author's calculations (2017).

3.3 Characteristics of respondents

3.3.1 Gender of respondents

Figure 3.3 presents data on the gender of the household heads. Of the 301 households interviewed, 166 (55.1%) had male household heads and 135 (44.9%) were female. According to Nowakowski (2002), female farmers comprise 8% of the world's population, and men 11%, therefore looking at the results, this means that the number of female farmers is increasing.

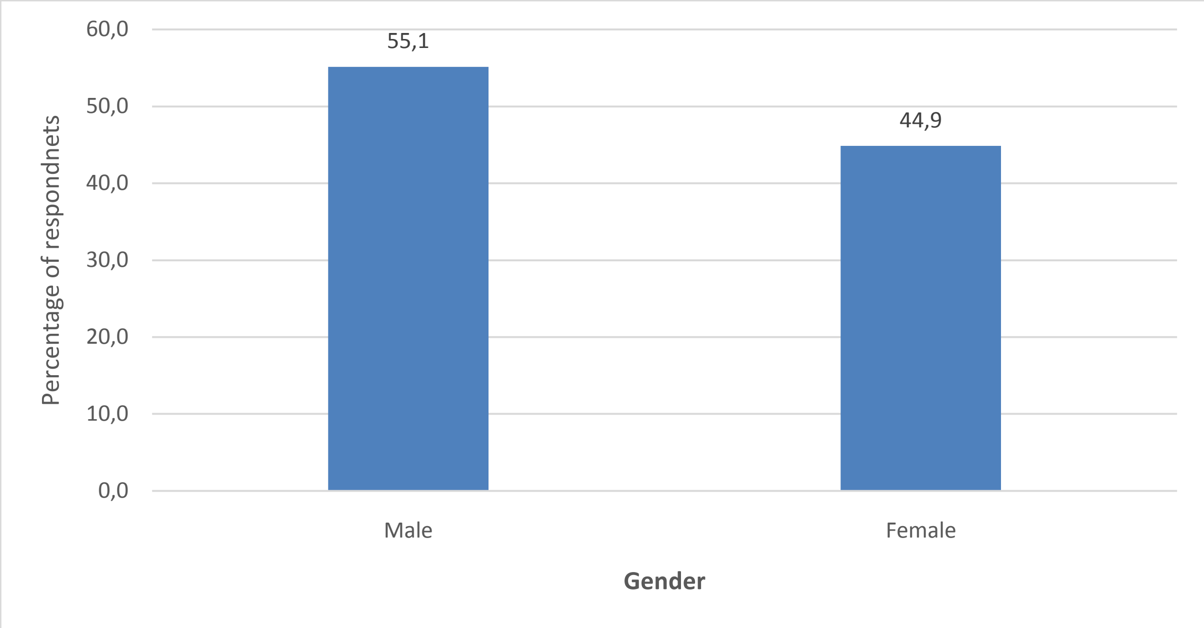

Figure 3.3: Gender of respondents

Source: Author's calculations (2017).

3.3.2 Age, farming experience and household size

Table 3.2 shows the descriptive statistics in terms of the mean and standard deviation of the socio-economic characteristics of smallholder farmers for age, household size and years of farming experience.

Table 3.2: Descriptive statistics of age, farming experience and household size of respondents.

	Minimum	Maximum	Mean	Std deviation
Age	19	91	53.40	15.330
Farming experience	1	74	19.18	13.689
Household size	1	14	3.77	1.996

Source:Author's calculations (2017).

The table shows that the youngest household head was 19 years old, while the oldest was 91 years old, and the mean age was 53 years. Furthermore, the minimum farming experience was one year, while the maximum was 74 years, with a mean of 19 years of farming experience. The results also show that the minimum household size was one and the maximum household size was 14, with a mean of four. This means that, on average, smallholder farmers in Thaba 'Nchu are relatively middle aged, with many years of farm experience and small household sizes. The results are similar to those of a study by Nyam(2017), who found that smallholder farmers in Thaba ‘Nchu were on average 54 years old and have an average of four people in their household.

3.3.3 Education level of respondents

The education levels of the respondents are presented in Figure 3.4. The education level of the household heads was categorised into no formal education, primary, secondary, middle college certificate or diploma, university degree and doctorate degree. College certificate is a professional certificate or diploma lower than a university degree, typically vocational secondary education, while a doctorate is the highest academic qualification.

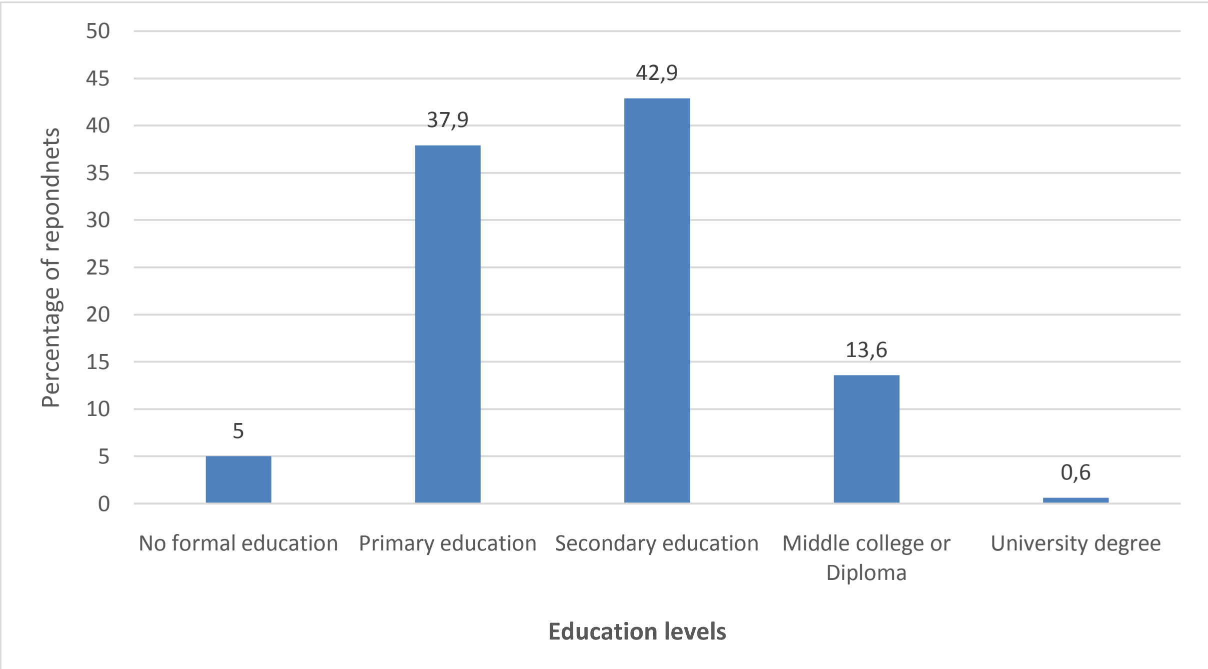

Figure 3.4: Education level of respondents

Source:Author’s calculations (2017).

In this study, primary education shows that the household head has obtained seven years of formal schooling, secondary school is an additional five years, college certificate or diploma is another years, while a university degree is three to four further years of formal schooling. The frequencies of household heads who had attained these levels of education are provided in Figure 3.4. The survey results in Figure 3.4 show that 5% of the household heads in Thaba ‘Nchu had no formal education, 37.9% had completed primary education, 42.9% had obtained secondary education, while 13.6% had a college certificate or diploma and only 0.6% had attained university education (degree and doctorate). This is consistent with the finding of Stats SA (2011), which found that 4.3% of farmers have no formal schooling.

3.3.4 Marital status of respondents

The marital status of the respondents is presented in Figure 3.5. The marital status of the household heads is categorised as single, married, widowed, divorced and separated.

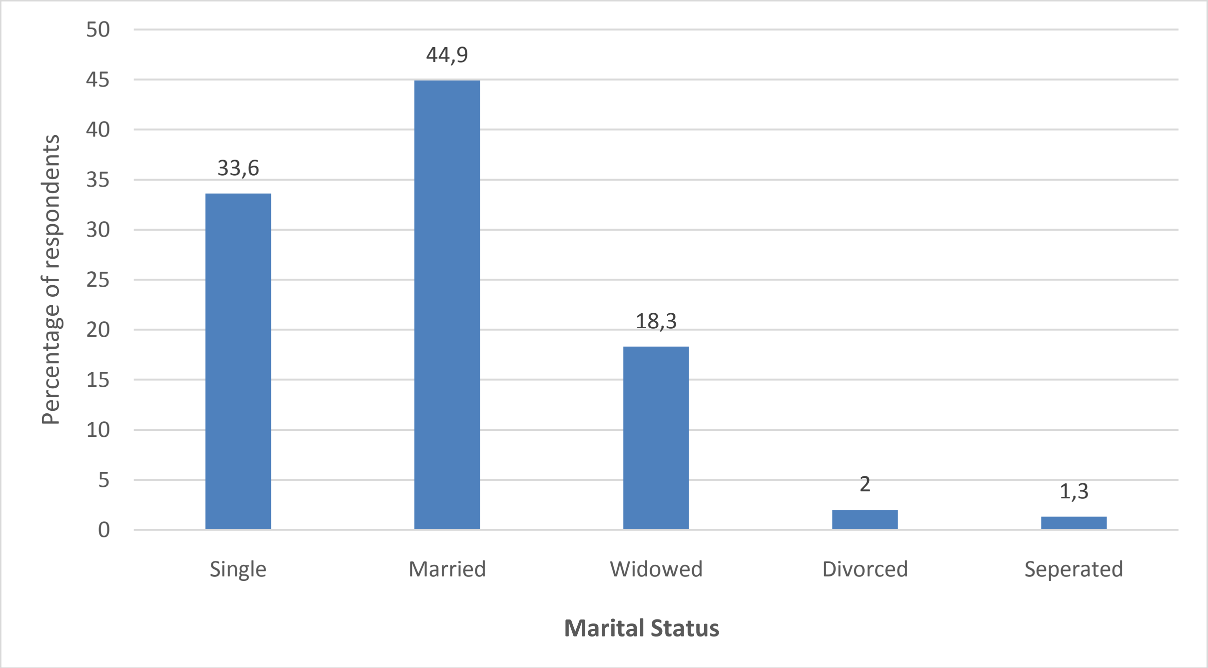

Figure 3.5: Marital status of respondents

Source:Author’s calculations (2017).

From Figure 3.5 it can be seen that 44.9% of household heads were married, 33.6% were single, 18.3% were widowed, 2% were divorced and 1.3% were separated. From the data presented, it shows that most smallholder farmers in Thaba ‘Nchu are married, and some are single. This finding is consistent with the results of Mudombi (2011), who found that most household heads in Zimbabwe were married.

3.3.5 Income level of respondents

The monthly income level of the respondents is presented in Figure 3.6. The monthly income of the respondents was categorised into less than R2 000, R2 001 to R5 000, R5 001 to R10 000, R10 001 to R20 000 and above R20 000.

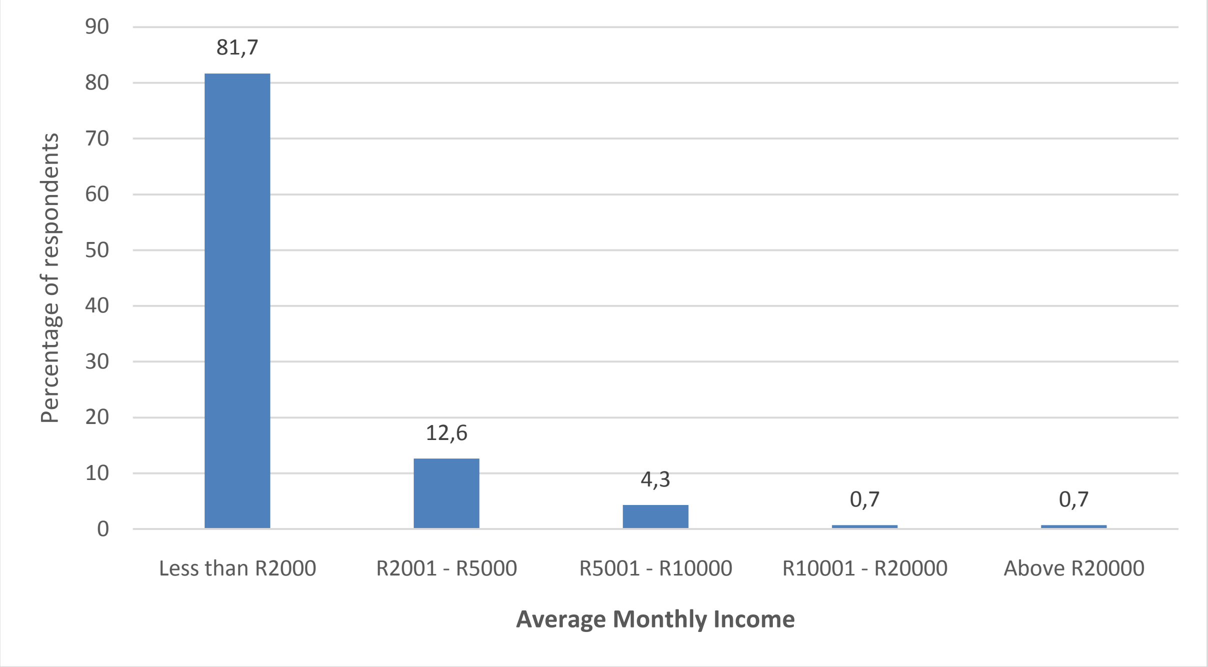

Figure 3.6: Average monthly incomes per household

Source:Author’s calculations (2017).

Figure 3.6 shows that 81.7% of the household heads earned less than R2 000 a month on average, while only 12.6% of households earned between R2 001 andR5 000.Few households earned more than R5 000 to R20 000 a month, which shows that the source of livelihood for farmers in Thaba ‘Nchuis agriculture because the majority of their income comes from agriculture. Therefore, during droughts, it is difficult to cope. The annual income of agricultural household heads in Thaba ‘Nchu shows that those with no income comprise 26.6%, those earning between R1 and R4 800 comprise 3.8%, 51.3% earn between R4 801 and R38 400,15.0% earn between R38 401 and R307 200, and only 1.9% earn more than R307 201(Stats SA, 2017).

3.3.6 Respondents' access to climate information

Figure 3.7 presents the respondents' access to climate to information. The respondents were asked if they received Early Warning System information and climatic advisories about drought.

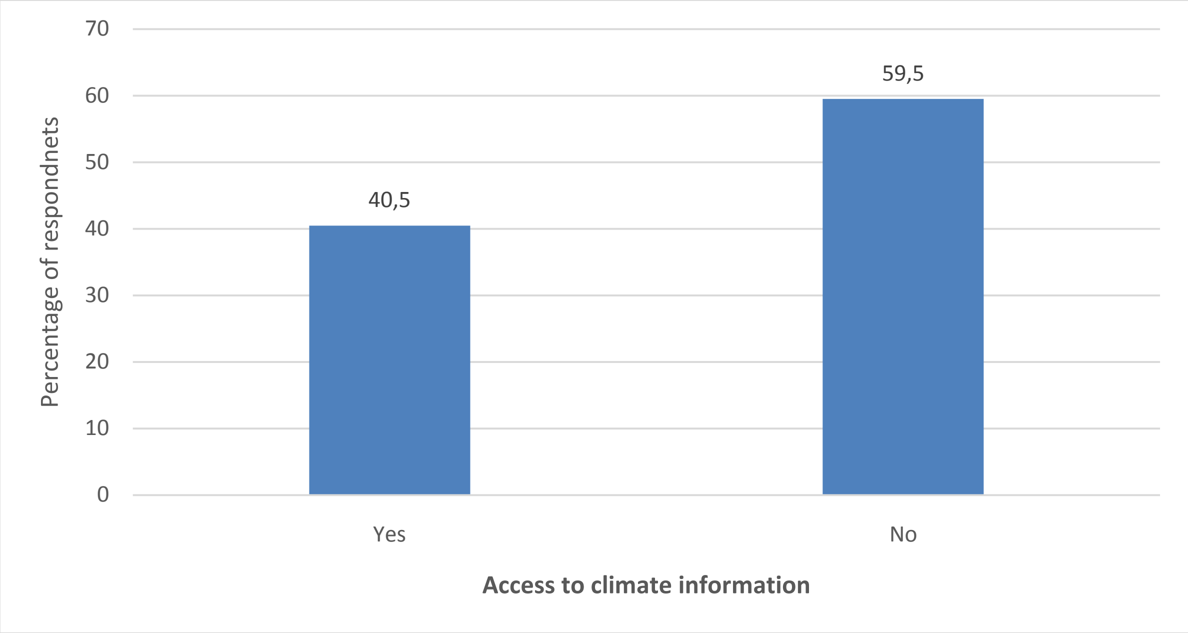

Figure 3.7: Access to climate information

Source:Author's calculations (2017).

Figure 3.7 shows that 40.5% of household heads had access to climate information and 59.5% did not have access to climate information. It can be concluded that more households have no access to climate information. This is similar to a study by Mandleni and Anim (2011), who found that most livestock farmers who were unsure of climate change were not receiving climate information.

3.3.7 Farmers' awareness of drought

The farmers' awareness of drought is presented in Figure 3.8. The respondents were asked if they were more aware, less aware, whether they did not see any difference or they did not know or were not aware of the frequency of drought in the past 10 to 12 years.

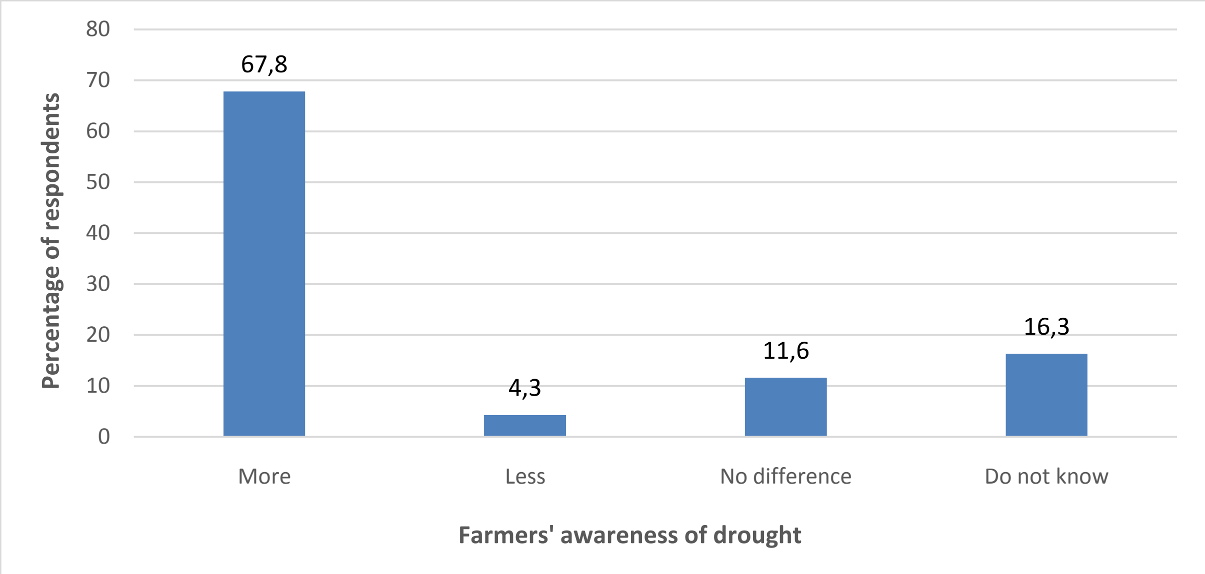

Figure 3.8: Farmers’ awareness of drought

Source:Author’s calculations (2017).

The results in Figure 3.8 show that 67.8% of the respondents were more aware that drought had become more frequent in the past 10 to 12 years, 4.3% were less aware, 11.6% said they saw no difference in drought events and 16.3% did not know or were unaware. Moranga (2016) found that respondents were aware of climate change. Generally, farmers had observed an increase in the average temperature and rainfall variability, and a decline in the mean amount of rainfall. Only a small fraction of farmers had not observed any changes in climate (Moranga, 2016).

3.3.8 Respondents' access to extension services

Figure 3.9 shows how many farmers in Thaba 'Nchu had access to extension services.

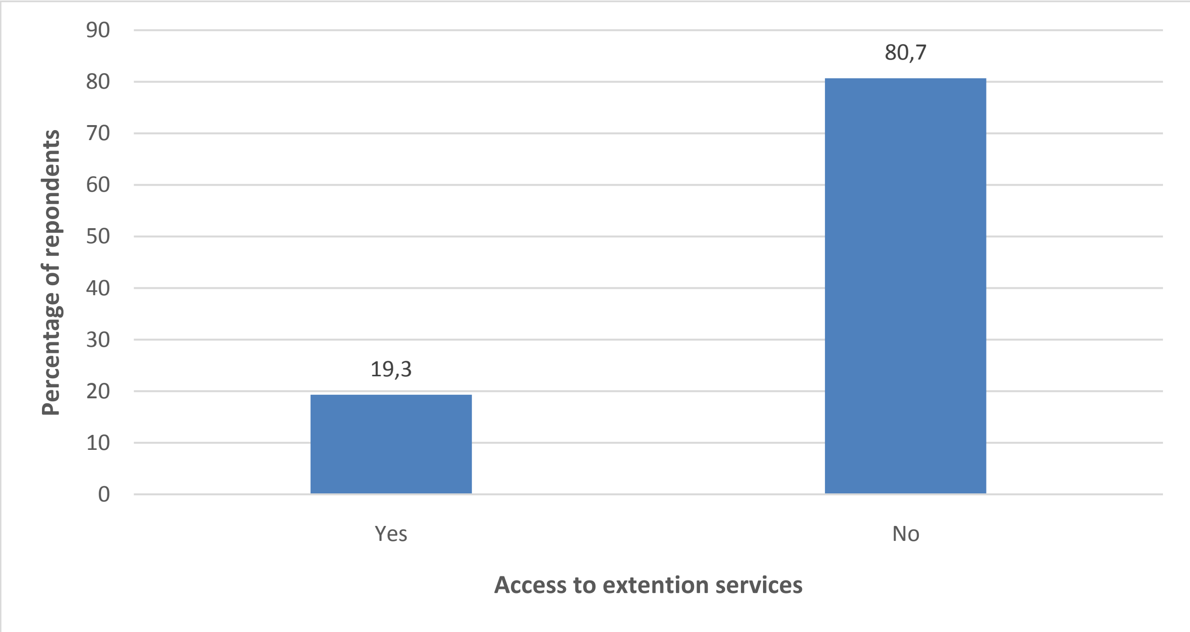

Figure 3.9: Access to extension services

Source:Author's calculations (2017).

Figure 3.9 shows that 80.7% of the respondents in Thaba 'Nchudid not have access to extension services, while only 19.3% had access. Therefore, the majority of the smallholder farmers in Thaba'Nchu do not have access to extension services, which makes them even more vulnerable to drought. This is consistent with a study by Nyam (2017), who found that more than half of sheep producers in Thaba 'Nchu did not have access to extension services.

3.4 Procedures

3.4.1 Determining farmers' perceptions of drought

The statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 21.0 of 2013. The analysis of farmers' perceptions to drought was carried out using a quantitative descriptive analysis, which included descriptive statistics such as frequency tables, graphs, pie charts, bar charts and tables.

3.4.2 Determining farmers' levels of vulnerability to drought

To determine farmers' levels of vulnerability to drought, quantitative approach was used. The sustainable livelihoodframeworkwas used as the basis for analysis. The framework includes different measures of capitals, namely human, financial, physical, social and natural capitals (Muyambo2017). For this study, institutional, cultural and political capitals were also included. The approach uses primary data from the questionnaires to construct the index/ratings. Vulnerability was calculated as weight "*x*" ratings, with the weight being made up of sums that add up to 1 for each and capital, and the ratings from 1 to 5 in the questionnaire, making use of the Statistical Package for Social Sciences (SPSS) version 21.0 (2013).

3.4.3 Identify the current coping/adaptation strategies used by farmers in Thaba 'Nchu

The identification of current coping/adaptation strategies used by farmers in Thaba 'Nchu was carried out using a quantitative data analysis. Options were given in the questionnaire that farmers had to rank and select the answer most applicable to them.

3.4.4 Identify the livelihood asset variables used by farmers in Thaba 'Nchu

Communities that succeed in supporting sustainable development considerer seven kinds of capitals (Jordaan 2012). For this study, only six capitals were used namely; human, social, economic, institutional, natural and political becausethey are the 'capitals' that they have access to and control overin order to create livelihoods. Different indicators were used for every capital to indicate how vulnerable farmers are to drought in the questionnaire. Farmers were asked to indicate their level of vulnerability using the scale of 1 to 5 with the indicators under all the six capitals.

3.4.5 Factors influencing the choice of adaptation strategies

Factors that influence the choice of adaptation strategies were determinedusing the multinomial logit (MNL) model. A multinomial logit statistical model is used when there are several possible categories into which the dependent variable can fall. The advantage of using a MNL model is its computational simplicity in calculating the choice probabilities, which are expressible in analytical form (Deressa et al. 2009). This model provides a convenient closed form for underlying choice probabilities, with no need for multivariate integration, making it simple to compute choice situations characterised by many alternatives. In addition, the computational burden of the MNL specification is made easier by its likelihood function, which is globally concave (Hassan and Nhemachena2008). The main limitation of the model is the independence of the irrelevant alternatives (IIA) property, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Deressaet al. 2009; Hassan and Nhemachena2008).

Multinomial logit model

The MNL model allows household characteristics to have different effects on the relative probabilities between any two choices. The MNL model for adoption of a specific choice specifies the following relationship between the probability of choosing A_i and the set of explanatory variables *x*, as (Greene 2003):

$$\Pr(A_i = j) = \frac{\exp^{B_j x_j}}{1 + \sum_{k=1}^{j} \exp^{B_k x_i}} \quad (1)$$

where $\beta_j$represents the set of regression coefficients associated with the outcome of the independent variable X. Equation (1) can be normalised to remove indeterminacy in the model by assuming that β_j= 0, and the probabilities can be estimated as:

$$\Pr(A_i = j / x_i) = \frac{\exp^{\beta_j x_i}}{1 + \sum_{k=1}^{j} \exp^{\beta_k x_i}}, \ j = 0,1...j, \beta_0 = 0 \quad (2)$$

Estimating equation (2) yields J log-odds ratio.

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = x_j^i \left(\beta_j - \beta_k\right) = x_j^i \beta_k, \text{ if } K = 0 \quad (3)$$

The choice of drought-adaptation strategies are therefore the log-odds in relation to the drought-related strategies that serves as the base alternative. According to Greene (2003), the coefficients of the multinomial logit are difficult to interpret, and associating β_j with the j_{th} outcome is tempting and misleading. The marginal effects are usually derived to explain the effects of independent variables in terms of probabilities, as presented in equation (4).

$$\frac{\partial p_j}{\partial x_i} = \mathrm{P}_j \left[\beta_j - \sum_{k-o}^{j} \mathrm{P}_k \beta_j \right] = \mathrm{P}_j \left(\beta_j - \mathrm{B} \right) \tag{4}$$

The marginal effects measure the expected change in the likelihood of a choice of a particular climate-related strategy with respect to a unit change in an exogenous variable.

The empirical model was specified as:

$$\begin{aligned} Y_{ij} &= \beta_0 + \beta_1 Age + \beta_2 Educ + \beta_3 HHsize + \beta_4 Expr + \beta_5 Skills + \beta_6 Gender \\ &+ \beta_7 Mstat + \beta_8 Sesnfar + \beta_9 Inco + \beta_{10} DroExp + \beta_{11} PerVul + \beta_{12} Perc + \\ &\beta_{13} HCI + \beta_{14} SCI + \beta_{15} ECI + \beta_{16} ICI + \beta_{17} NCI + \beta_{18} PCI + \varepsilon_i \end{aligned} \tag{5}$$

Explanatoryvariable used in the multinomial logit estimation

Table 3.3 presents the explanatory variables hypothesised to influence the farmers' choice of adaptation strategies. Table 3.3 shows the variables used in the model, the measurement index, and the expected sign of influence of the factors. The variables that influence farmers' choice of adaptation strategies include age, education, household size, farming experience, farming skills, gender, marital status, farming season, household income, drought experience, perceived vulnerability, perception of drought, access to climate Information, farmers' awareness of drought and access to extension services.

Table 3.3: Definition of independent variables for multinomial logit analysis.

Variable	Description	Expected sign
Age of household head	Age in years	±
Education level	Household head education level: *0 = No formal education 1 = Primary 2 = Secondary 3 = Middle-level college certificate or diploma 4 = University degree 5 = Doctorate*	+
Household size	The number of household dependants	±
Farming experience	Farming experience in numberof *years*	±
Farming skills	Any farming skills: *0=Yes 1=No*	+
Gender	Gender of household head: *0=Male 1 = Female*	±
Marital status of household head	Household head marital status*: 0 = Single 1 = Married 2=Widowed3 = Divorced 4=Separated*	+
Seasonal farming	Farming business seasonal: *0=Yes 1=No*	+
Household income	Average household income: *0=Less than R 2001 1=R2001-R5000 2 = R5 001-R10000 3=R10 001-R20 000 4=R20 001 and above*	+
Drought experience	Experienced drought: *0=Yes 1=No*	-
Perceived vulnerability	Farming operation's level of risk to drought *1=Very High 2 = High 3 = Moderate 4=Low 5=None*	-
Perception of drought	Ever experienced drought in the past five years*0=Yes 1=No*	±
Human capital index	Age, education, gender, skills and experience	±
Social capital index	Family support, formal and informal groups, networks and connections	±
Economic capital index	Access to information, insurance, marriage, salary/wages/income,alternativesources of income, unemployment	±
Institutional capital index	Farmers associations, environmental health, NGOs, extension service	±
Natural capital index	Soil erodibility, ground water, irrigation land	±
Political capital index	Political stability, policies, governance, government support, government drought scheme	±

Source: Author's compilation.

3.5 Chapter summary

The Free State agricultural sector, just like the national agricultural sector, comprises crop production, animal production, horticulture, dairy farming, game farming, aquaculture, fruit production and agro-processing. Approximately 14.5% of South Africa's commercial farming takes place in the province (Free State Development Corporation, 2016). This sector is critical to the well-being of the province, both as the provider of food and a major employer. It accounts for 26.4% of South Africa's field crops and 15.9% of all its animals. The Free State is responsible for 15% of South Africa's gross agricultural income (Free State Development Corporation, 2016).

The primary data was collected using structured questionnaires. Proportionate stratified sampling was used. From Thaba 'Nchu, a total of 301 farmers from14 chosen villages were sampled for the study. The survey shows that, ofthe 301 farmers interviewed, the majority (166) were males. The survey data indicate that the youngest farmer was 19 years old, with the only one year farming experience. Most of the smallholder farmers had attained at least secondary education. Most are married and the majority earn an average monthly income of R2 000 or less. Furthermore, the majority of smallholder farmers in Thaba 'Nchu have no access to climate information. The majority of the farmers are more aware of drought having become more frequent in the past 10 to 12 years. More farmers do not have access to extension services.

CHAPTER 4: RESULTS AND DISCUSSION

This chapter is presented into five sections, the analysis of the results that was performed to meet the objectives of the study, as well as the discussion of the results. The first section discusses the results on the farmers' perceptions of drought. The second section includes a discussion on the farmers' level of vulnerability to drought using different capitals. The third section includes a discussion on coping and adaptation strategies used by farmers in Thaba 'Nchu, identifying coping strategies used during the 2015/2016 drought. The fourth section includes adiscussion on the factors influencing the choice of coping and adaptation strategies and the last section presents the summary of the chapter.

4.1 Farmers' perceptions of drought

It is important to understand the farmers' perceptions of drought, as this gives an insight into their previous drought experiences, their level of understanding and awareness of drought, and their sources of information for whether or not they believed when informed that there would be a drought incidence (Olaleye 2010).

4.1.1 Perceptions of the nature of drought

The farmers' perceptions of the nature of drought are presented in Figure 4.1. The nature of drought was given as a manmade disaster or a natural disaster, and the respondents were asked their perceptions with the options of strongly agree, agree, undecided, disagree or strongly disagree.

Figure 4.1 shows that 89% of the respondents perceived drought as a natural disaster and only 0.3% did not perceive it as a natural disaster, therefore the majority perceived drought as a natural disaster. Also, when the same farmers were asked if they thought drought was a manmade disaster, 46.5% strongly agreed that drought is a manmade disaster, while 24.3% farmers strongly disagreed that drought was a manmade disaster. Drought has different meanings to the respondents based on their physical environment, type and degree of involvement in agricultural activities, and its level of impact on their financial well-being(Ashraf and Routray 2013; Geogr 1997). Since 89% strongly believed that drought is a natural disaster, it can be concluded that the farmers actually perceive the nature of drought to be a natural disaster.

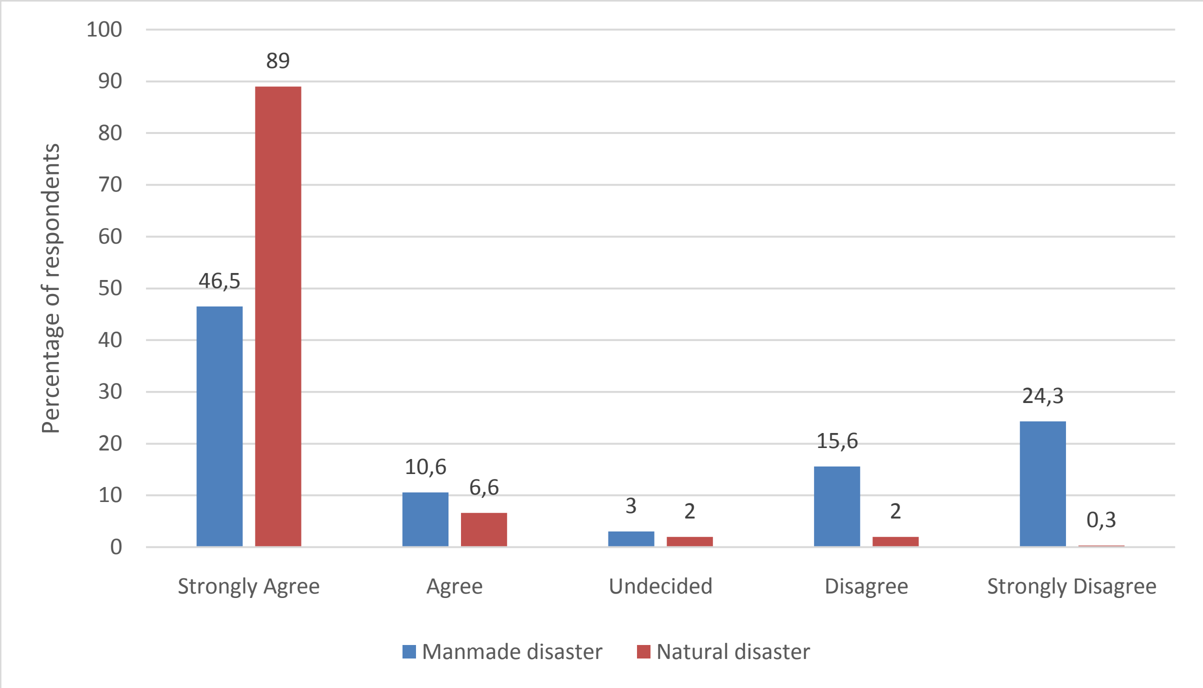

Figure 4.1: Farmers' perceptions of the nature of drought

Source:Author's calculations (2017).

4.1.2 Perceptions of the frequency of drought

Farmers were asked how they perceived the frequency of drought in the years to come and their perceptions of the frequency of drought are presented in Figure 4.2.

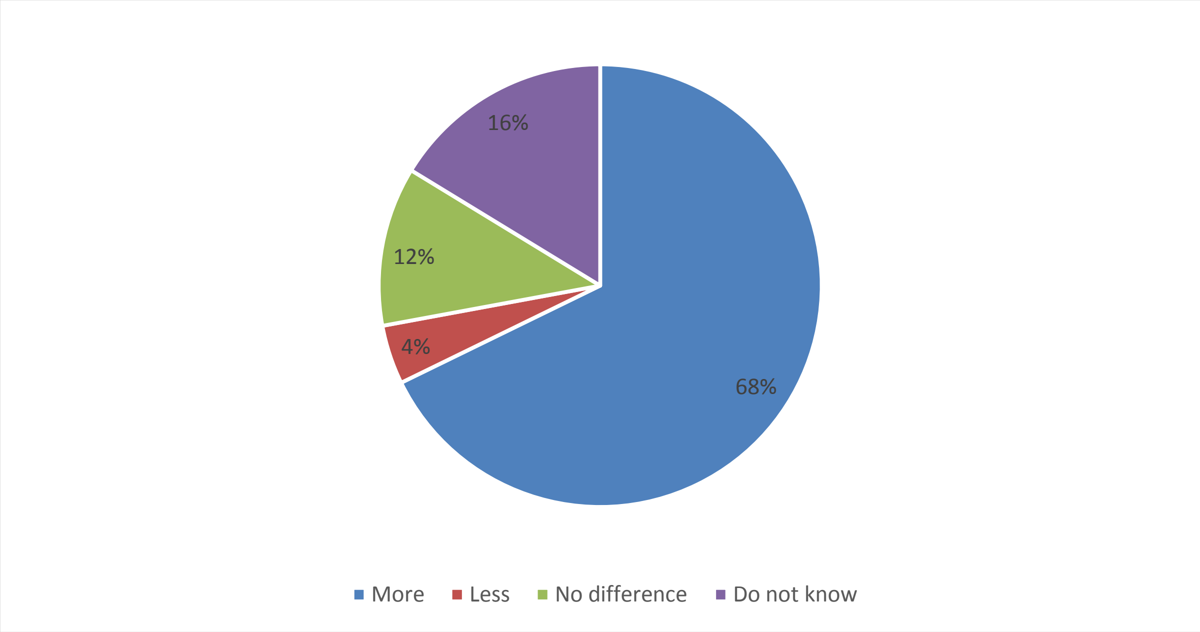

Figure 4.2: Farmers' perceptions of the frequency of drought

Source:Author's calculations (2017).

Figure 4.2 shows that 68% of the farmers perceived that drought was going to be more frequent in the coming years, 4% of the farmers perceived that drought would occur less frequently, 12% of the farmers were indifferent about the frequency of drought in the coming years, and 16% said they did not know what would happen. Their reasons were that they cannot predict what will happen in the future. The farmers that perceived that drought would occur more frequent said so because they thought drought was becoming more frequent due to the 2015/2016 drought, which affected and was still affecting them in 2017.

4.1.3 Perceptions of the effects of drought

The results for their perceptions of the effects of drought are presented in Table 4.1. The identified drought effects are vegetation loss, drying of water pans, resource conflicts, livestock migration, soil erosion, wildfires and lack of food and water for livestock. The effects were ranked from not severe to very severe according to each respondent.

Table 4.1: Farmers' perceptions of the effects of drought

Drought effects perception	Not severe		Not so severe		Moderate		Severe		Very severe	
	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq
Vegetation loss	10.6	32	2.7	8	16.3	49	22.9	69	47.5	143
Water pans drying	11.06	35	3.0	9	13.6	41	50.2	151	21.6	65
Resource conflicts	27.06	83	9.0	27	36.5	110	14.3	43	12.6	38
Livestock migration	31.6	95	18.6	56	19.9	60	18.6	56	11.3	34
Soil erosion	19.9	60	8.6	26	29.2	88	25.6	77	16.6	50
Wildfires	22.9	69	4.7	14	16.6	50	35.9	108	19.9	60
Lack of livestock food and drinking water	9.3	28	2.7	8	12.3	37	47.5	143	28.2	85

Source: Author's calculations (2017).

About 47.5% of the smallholder farmers in Thaba 'Nchu perceived vegetation loss as a very severe effect of drought, 2.7% perceived it as not so severe, 16.3% perceived it as moderate and 10.6% do not perceived it as severe. The respondents perceived the drying of water pans (50.0%) as one of the most severe drought effects, while 3.0% perceived it as not so severe, 16.3% perceived it as moderate and 47.5 perceived it as very severe. Lack of livestock food and drinking water (47.5%) was perceived as severe, with 9.3% who perceived it as not severe, 2.5% who perceived it as not so severe, 12.3% who perceived it as moderate and 28.2% who perceived it as very severe. About 21.06%, 31.6% and 22.09% of the respondents found resource conflicts, livestock migration and wildfires to be the least severe drought effects in Thaba 'Nchu. The respondents perceived soil erosion as a moderate (29.2%) effect of drought. Furthermore, the farmers in Thaba 'Nchu perceive vegetation loss and lack of livestock food and drinking water as very severe. The reason why the severity of the drought effects differs is because the majority of farmers in Thaba 'Nchu are livestock farmers and some are crop farmers, therefore the effects differ. Some drought perceptions have been shown to have no impact on decision making and are considered "non-operational" (Kirkby 1974).

4.2 Farmers' levels of vulnerability to drought

The development and use of indicators to analyse social conditions has a long history and began around the 1830s, when social statistics were used to improve public health conditions in Europe and the USA, well before the development of environmental indicators (Cobb and Rixford 1998). This section explains how vulnerable farmers are to drought, looking at the different demographics.

4.2.1 Total vulnerability of farmers

Table 4.2 shows the vulnerability index of farmers derived from their access to various capitals such as the human, economic/financial, social, natural, political and institutional capitals. The human capital index is a sum of indicators such as age, education, gender, experience and skills. All these human capital indicators are important because they make up the demographics of the farmers. The financial/economic capital index is a sum of access to information about drought, insurance for farming operations, marriage, source of income for farmers, and unemployment; all these factors contribute towards drought because, during such times, all economic activities change. The social capital index is a sum of family support, formal and informal groups, networks and connections that the farmer has. All the social indicators contribute highly towards vulnerability todrought. The reason the natural capital is so vulnerable to drought is because the farmers in Thaba ‘Nchu resort to irrigation during drought periods. For the purpose of this study, two more capitals were added – institutional capital, which is the sum of indicators such as farmer associations, environmental health, NGOs and extension services, and political capital, which is the sum of political stability, policies, governance, government drought scheme and government support. The institutional and political capitals contribute to farmers’ vulnerability to drought in Thaba ‘Nchu because the farmers depend on government support during drought periods.

Table 4.2: Total vulnerability of farmers

Variable	Obs	Std. deviation	Mean	Min	Max
Human capital index	299	0.93	3.13	1	5
Financial/economic capital index	300	0.97	2.58	1	4.8
Social capital index	301	1.04	2.82	1	5
Natural capital index	300	1.37	2.94	1	5
Political capital index	299	1.22	2.73	1	5
Institutional capital index	300	1.16	2.63	1	5
Total vulnerability index	295	4.32	14.22	5.10	24.70

Source: Author’s calculations (2017).

Equal weighting was applied to the various indicators, following the approach of Cutter, Boruff, and Shirley (2003), who argue that there is no theoretical rationalisation for assigning different weights to indicate different levels of significance to individual factors’ contribution to vulnerability (Cutter, Boruff, and Shirley 2003). From Table 4.2, one can see that human capital has the highest index, of 3.13, followed by natural capital with an index of 2.94 and social capital with an index of 2.82. Political and institutional capitals had indexes of 2.73 and 2.63 respectively. The capital with the lowest vulnerability index is financial/economic capital, with an index of 2.58. Therefore, the high capital index means that the farmers are more vulnerable in terms of human capital, while the lowest capital index means the farmers are less vulnerable in terms of financial/economic capital.

The total vulnerability was calculated by summing the individual capital indexes. It is the sum of human capital, social capital, economic capital, institutional capital, natural capital and political capital.

The vulnerability spider diagram below shows the six livelihood assets (human, economic/financial, social, natural, political and institutional capitals), ranging from 0 (least vulnerable) to 3.5 (most vulnerable). Thaba ‘Nchu was more vulnerable in terms of human capital indicators such as age, education, gender, experience and skills. The human capital index was most vulnerable in terms of livelihood strategies. The financial/economic capital index was less vulnerable, with a mean of 2.58. This means that the farmers are less vulnerable in terms of financial/economic capitals. According to a study by Aduet al. (2017), the socio-economic profile, showed greater vulnerability compared to the other capitals. Therefore, possible solutionshould be tailored at addressing such a capital with high vulnerability in order to reduce their impacts.

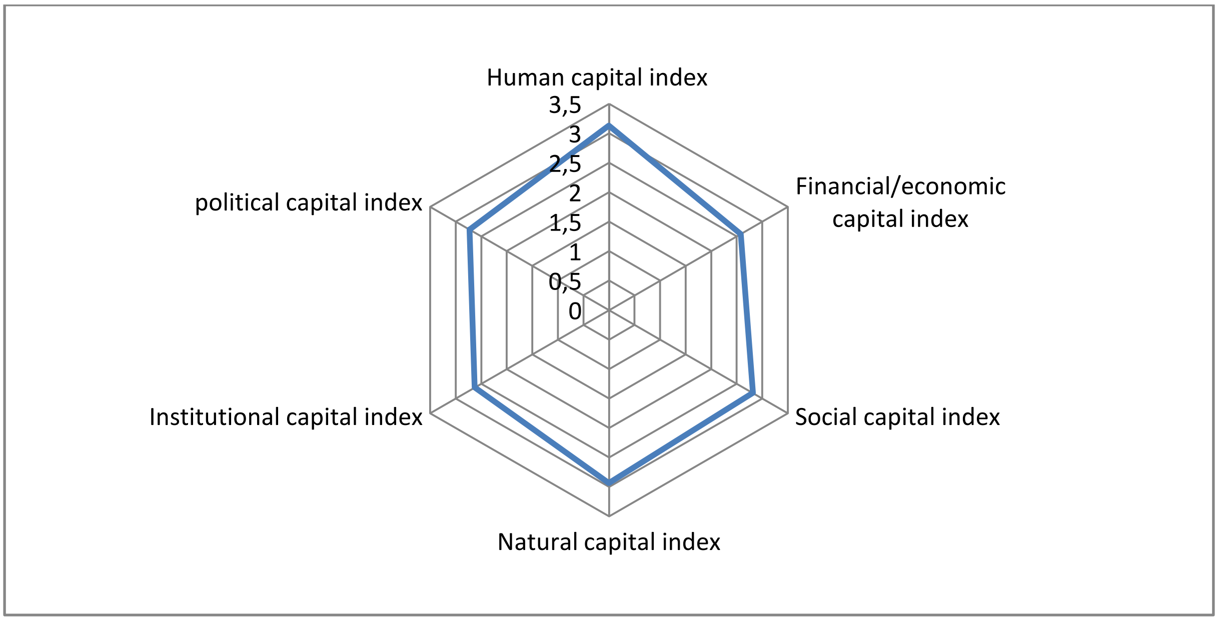

Figure 4.3 Vulnerability spider diagram of the livelihood assets/capitals

Source: Author’s calculations (2017).

4.2.2 Cross-tabulation of total vulnerability and socio-economic factors

Table 4.3 provides a cross-tabulation of total vulnerability and socio-economic factors. The table shows a slight difference in vulnerability between males and females, with males being more vulnerable compared to females in all the vulnerability capitals. Females are 13.95% less vulnerable relative to males, who are at 14.45% on the total vulnerability index. The reason for the higher vulnerability of males is attributed to the number of males in the study area, because there are more male farmers compared to femalefarmers. The balance of decision making between men and women concerning farming was generally in favour of men, making women more vulnerable to drought (Jordaan and Adoko 2014)

Table 4.3: Cross-tabulation of total vulnerability and socio-economic factors

Socio-economic factors		**Total vulnerability**
Gender	Male	14.45
	Female	13.95
Education	No formal education	15.49
	Primary education	13.85
	Secondary education	14.20
	Middle college diploma	14.59
	University degree	14.7
Skills	Farming skills	13.99
	No farming skills	16.58
Marital status	Single	14.65
	Married	14.09
	Widowed	14.04
	Divorced	12.4
	Separated	12.95
Income	Less than R2000	14.38
	R2001-R5000	13.16
	R5001-R10000	13.13
	R10001-R20000	13.1

Source: Author's calculations (2017).

Farmers with no formal education are more vulnerable. In all the vulnerability capitals, it is clear that the less educated you are, the more vulnerable you are, simply because education is important in building a drought-resilient community. Therefore, farmers who are educated are not as vulnerable as the farmers with no/less education. Education turns out to be more important than income in reducing disaster vulnerability; education may indirectly reduce vulnerability through many other means (Muttarak and Lutz 2014).

The less skilled a farmer is, the more vulnerable he/she is to drought. The influence on total vulnerability of no farming skills (16.58%) shows more vulnerability compared to a farmer with farming skills (13.99%). Farming skills are very important because, during drought, the farmer needs the right skills to be able to deal with drought. The effect of indigenous knowledge on either resilience or susceptibility to drought is of particular interest in agriculture (Jordaan 2012; Jordaan and Adoko 2014). The results show that single (14.65%) and married people (14.09%) are more vulnerable to drought than divorced (12.4%) and separated people (12.95), because those who are married and single are the majority and they are both affected, while those who are divorced and separated are few, therefore they are not as vulnerable. Furthermore, those who earn an average monthly income of less than R 2000 (14.38%) are more vulnerable compared to people who earn between R10 001 and R20 000 per month. The reason for this is that the less money you earn, the more vulnerable you are during times of drought. Dependence on social grants already indicates marginalisation and poverty (Adger, Arnell and Tompkins 2005), hence the inability to cope and recover from drought, which makes these respondents more vulnerable (Muyambo 2014).

4.3 Coping and adaptation strategies used by farmers in Thaba 'Nchu

4.3.1 Identified coping strategies used during the 2015/2016 drought

Coping capacity is the ability of people, organisations and systems, using skills and resources, to face and manage adverse conditions and disasters (UN/ISDR 2009). This section looks at the different coping strategies chosen by the farmers based on their available resources and external help. Table 4.4 presents the identified coping strategies and Figure 4.4 presents the adaptation measures that were used by the farmers during the 2015/2016 drought.

Table 4.4: Identified coping strategies used during the 2015/2016 drought

Coping strategies	Yes		No	
	%	Freq	%	Freq
NGO intervention in the community	10.6	32	89.4	269
Seek new sources of food	5.0	15	95.0	286
Seek employment elsewhere	16.6	50	83.4	251
Keep reserves	8.6	26	91.4	275
Rainwater harvesting	27.2	82	72.8	219
Maintaining flexibility	1.0	3	99.0	298
Get assistance from government	25.2	76	74.8	225

Source:Author's calculations (2017).

From Table 4.4 it is clear that the most frequently used coping strategy in Thaba 'Nchu during the 2015/2016 drought was rainwater harvesting, which was used by 27.2% of the farmers, followed by assistance from the government, which was used by 25.2% of the farmers. Also, 16.6% of the farmers sought employment elsewhere in order to cope with the drought, and 10.6% of the farmers depended on NGO interventions in the community as a means of adapting to drought. Smallholder farmers in Thaba 'Nchu do not maintain flexibility, as 99.0% of the respondents did not use maintaining flexibility as a coping strategy. Furthermore, the least used coping strategies in Thaba 'Nchu were seeking new sources of food (5.0%) and keeping reserves (8.6%). The results show that the second most used coping strategy was assistance from government, which is similar to the findings of Shoroma (2014), who found that the farmers of Setlagole village were dependent on the government to assist them with the necessary relief mechanisms to reduce the impact of drought.

The study also tried to discover whether the various adaptation measures used by farmers in Thaba 'Nchu during the 2015/2016 drought were implemented, planned, effective/necessary or not relevant/necessary. Figure 4.4 represents the results for the different adaptation measures according to the respondents.

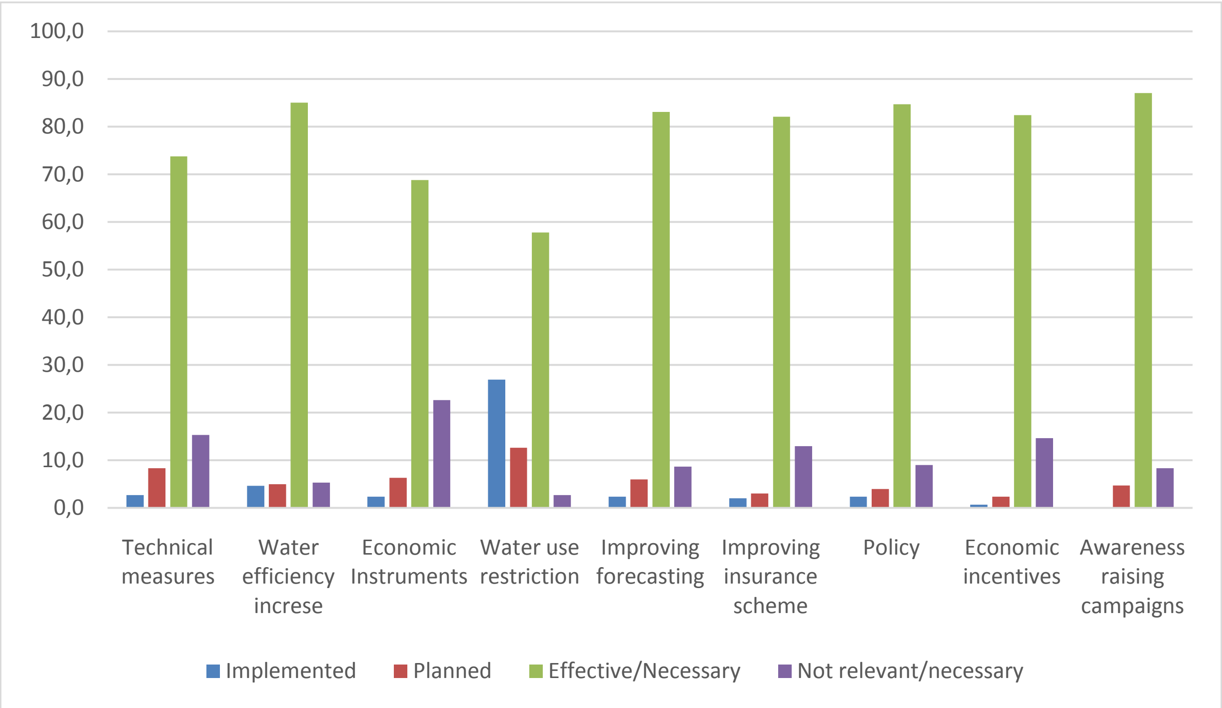

Figure 4.4: Different adaptation measures according to respondents

Source:Author's calculations (2017).

Figure 4.4 shows that only 2.7% of the respondents implemented technical measures as a type of adaptive strategy, 8.4% planned to do so, 73.8% found it effective/necessary and 15.3% said it was not relevant/necessary. It also shows that 4.7% of the respondents implemented water-use efficiency, 5.0% planned to use it, 85.0% found it effective/necessary to adapt while 5.5% found it not relevant/necessary. Furthermore, 2.3% of the respondents implemented economic instruments as adaptation measure, with only 6.3% of the respondents who planned to do so, 68.8% found it to be effective/necessary and 22.6% found it not relevant/necessary as an adaptation measure.

A total of 26.9% implemented water-use restriction as an adaptation measure, with 12.6% who planned to do so, 57.8% who found the adaptation strategy effective/necessary, and only 2.7% who found it not to be necessary/relevant. Improving forecasting was implemented by only 2.3% of the respondents, only 3.0% planned it, with 83.1% who found it effective/necessary and 8.6% of respondents who found it not relevant/necessary. Only 2.0% of the respondents implemented insurance scheme improvement as an adaptation measure, 3.0% planned it, 82.1% found it to be effective/necessary and 13.0% did not find it relevant/necessary.

Furthermore, policy that includes new/revised legislation, bills, Acts of Parliament, etc. wasonly implemented by 2.3% of the respondents, with only 4.0% who planned it; 84.7% of the respondents found it effective/necessary and 9.0% found it not relevant/necessary. Only 0.7% of the respondents implemented economic incentives as an adaptation measure, with 2.3% who planned to do so, 82.4% who found it to be effective/necessary and 14.6% who found it not relevant/necessary. However, no respondent implemented an awareness-raising campaign as adaptation measure, with 4.7% who planned to do so. Also, 87.0% found it to be effective/necessary, with just 8.3% who did not find it effective/necessary. The results show that most adaptation measures are effective/necessary, with only a few implemented in Thaba‘Nchu. This observation demonstrates how sustainable development that helps reduce vulnerability needs to be undertakenconcurrently with adaptation for it to be successful (Schipper 2007; Small 2007).

4.4 Factors influencing the choice of coping and adaptation strategies

The multinomial logit model was used to examine the factors that influence farmers’ choice of coping/adaptation strategies during drought in Thaba ‘Nchuin the Free State Province. In order to cope with the effects of drought, different coping strategies were adopted by the farmers based on the limited resources available at the household level, as well as help from external sources. This section looks at the choices that influenced such coping strategies. Tables 4.4 and Table 4.5present model estimates of the factors influencing farmers' choice of adaptation strategy. The log-likelihood test was employed to assess the overall significance of the independent variable in explaining the variations in the importance of coping strategies used by farmers. The coefficients are explained in relation to the 1%, 5% and 10% level of significance. The results include the following coping strategies: technical measures to increase supply, increasing efficiency of water use, economic instruments/external costs, restriction of water use, improving forecasting and improving insurance schemes.

Table 4.5: Estimates of the multinomial logit model on the choices of effective adaptation strategies.

Explanatory variable	**Technical measures**		**Water-use efficiency**		**Economic instruments**	
	Coefficient	z	Coefficient	z	Coefficient	z
Constant	0.280	0.31	5.713***	5.95	0.036	0.04
Gender	0.033	0.18	-0.132	-0.64	0.086	0.50
Age	-0.002	-0.29	-0.010	-1.35	0.011*	1.76
Household size	-0.014	-0.32	-0.006	-0.13	-0.047	-1.14
Seasonal farming	-0.060	-0.31	0.214	1.02	-0.191	-1.05
Drought frequency	0.055	0.73	0.179**	2.02	0.125*	1.75
Faming skills	0.727**	2.06	-0.004	-0.01	-0.279	-0.92
Primary education	-0.488	-1.18	0.034	0.08	0.348	0.89
Secondary education	-0.069***	-0.36	0.149	0.67	0.003	0.02
University degree	0.570	1.61	0.273***	0.75	0.391	1.32
Marital status	-0.051	-0.28	-0.116	-0.57	-0.252	-1.44
R2001 – R5000	1.004	1.57	-4.382***	-8.78	0.483	0.72
R5001 – R10000	1.774***	2.57	-4.058***	-6.26	0.950	1.37
R10001 – R20000	1.849***	2.36	-4.768***	-7.48	1.493*	1.83
Human capital index	0.066***	0.64	0.096	0.76	0.045	0.44
Social capital index	0.039	0.33	-0.119	-0.93	0.080	0.73
Economic capital index	-0.051	-0.35	0.484*	2.76	-0.361***	-2.40
Institutional capital index	-0.214	-1.50	-0.330	-2.11	0.018	0.13
Natural capital index	0.207	1.76	0.213*	1.75	0.287***	2.42
Political capital index	-0.295**	-2.18	-0.319	-2.26	-0.264**	-2.05
Number of observations	294		294		294	
Wald $chi^2(19)$	42.93***		443.95***		36.60***	
Prob> chi^2	0.0013		0.0000		0.0089	
Pseudo R^2	0.1370		0.1222		0.0959	

*= significant at 10%, **= significant at 5%, ***= significant at 1%

Source:Author's calculations (2017).

Table 4.6: Estimates of the multinomial logit model on the choices of effective adaptation strategies (continued).

Explanatory variables	Water-use restriction		Improving forecasting		Improving insurance scheme	
	Coefficient	z	Coefficient	z	Coefficient	z
Constant	0.171	0.19	-0.744	-0.80	6.222***	6.36
Gender	-0.314**	-1.89	-0.146	-0.74	-0.296	-1.52
Age	0.012**	2.04	0.009	1.34	-0.002	-0.35
Household size	-0.018	-0.44	0.007	0.17	-0.027	-0.60
Seasonal farming	-0.228	-1.27	-0.270	-1.28	-0.561**	-2.41
Drought frequency	-0.014	-0.20	0.184**	2.15	-0.039	-0.48
Faming skills	-0.428	-1.44	0.305	0.86	0.487	1.15
Primary education	0.736*	1.70	0.452	1.06	-0.493	-1.27
Secondary education	0.026	0.14	0.198	0.89	-0.089	-0.41
University degree	-0.060	-0.22	0.650***	1.95	0.282	0.72
Marital status	-0.381**	-2.28	0.095	0.48	-0.010	-0.04
R2001 – R5000	-0.428	-0.65	1.334**	2.10	-4.139***	-7.67
R5001 – R10000	-0.155	-0.22	1.663***	2.45	-3.174***	-4.41
R10001 – R20000	-0.503	-0.68	1.957**	2.40	-3.536***	-5.15
Human capital index	-0.083	-0.83	-0.182	-1.56	0.114	0.95
Social capital index	0.156	1.53	0.146	1.14	-0.009	-0.07
Economic capital index	0.168	1.19	0.004	0.02	0.017	0.11
Institutional capital index	-0.225	-1.62	-0.284*	-1.83	-0.198	-1.43
Natural capital index	0.098	0.89	0.346***	2.77	0.271**	2.31
Political capital index	0.012	0.10	-0.140	-0.94	-0.368***	-2.72
Number of observations	294		294		294	
Wald $chi^2(19)$	25.97		28.45*		349.06***	
Prob> chi^2	0.1310		0.0751		0.0000	
Pseudo R^2	0.0701		0.0867		0.1534	

*= significant at 10%, **= significant at 5%, ***= significant at 1%

Source: Author's calculations (2017).

Various studies have shown that gender is an important variable affecting adoption decisions at the farm level. The variable ***gender*** is statistically significant and negatively influences farmers' choice of water-use restriction as a coping strategy. This implies that female farmers are less likely to adopt water-use restriction as a coping/adaptation strategy. The findings is consistent with studies by Deressa et al. (2009), Mandleni and Anim (2007) and Tezeze et al. (2012), which found that male-headed households adapt more readily to climate change.

The ***age*** ofthe farmer was found to be statistically significant and to have a positive influence on the choice of economic instruments (e.g. water pricing) and water-use restriction as coping strategies. This means that, the older the farmer, the more likely he/she is to adapt economic instruments and water-use restrictions as coping strategies. This is in line with the findings of Ishaya and Abaje (2008), Maddison (2006) and Tazeze et al. (2012).

Seasonal farming was found to be statistically significant and to have a negative influence on improving insurance scheme as a coping strategy. This implies that seasonal farmers are less likely to adapt improving insurance as a coping strategy. The findings of Hassan and Nhemachena (2008) show thata warmer winter-spring promotes switching to the use of irrigation, multiple cropping, and mixing crop and livestock activities, especially under irrigation.

Drought frequency was found to be statistically significant and to have a positive influence on improving forecasting, water-use efficiency, and economic instruments. This implies that when, drought becomes more frequent, farmers are more likely to adopt water-use efficiency, improving forecasting and economic instruments as coping strategies. The findings are consistent with studies by Anim (1999), Araya and Adjaye (2001), Gould, Saupe, and Klemme (1989); Traoré, Landry, and Amara (1998), which found that farmers' awareness and perceptions positively and significantly affected their decisions to adopt coping measures.

Farming skills were found to be statistically significant and to have a positive influence on technical measures. This implies that farmers with farming skills are more likely to adopt technical measures as a coping strategy because the skills they have gathered while farming enable them to know the technical measures that they have to apply. This is consistent with the findings of Hassan and Nhemachena (2008).

Primary education, secondary education and university degree were found to be statistically significant and to have a positive influence on all six strategies as coping strategies, compared with the reference category (no education). Of all the significant variables, secondary education is negatively related to technical measures, while all the other variables are positively related. This implies that any form of education is important in order for farmers to be able to make informed decision on which adaptation strategy to choose. The findings is consistent with studies by Deressa et al. (2009), Igoden, Ohoji, and Ekpare (1990), Lin (1991), Maddison (2006), Norris and Batie (1987),and Ogunniyi (2011), who found that education increases the probability of adaption to climate change.

The ***marital status*** of farmers was found to be statistically significant and to have a negative influence on water-use restriction as a coping strategy. This implies that farmers who are married are less likely to adapt water-use restriction as a coping strategy. The finding is consistent with the study by Mudombi (2011), who found that marital status is negatively correlated to responsiveness.

Income in the brackets ***R2 001 to R5 000***, ***R5 001 to R10 000*** and ***R10001 to R20 000*** was found to be statistically significant and to have both a positive and negative influence on all six choices of coping strategies. Income between R2 001 and R5 000 had a positive influence on improving forecasting as coping strategy. Furthermore, income between R2 001 and R5 000 had a negative influence on water-use efficiency and improving insurance scheme as coping strategies. These results show that farmers must have income in order to adapt to improving forecasting as a coping strategy. A monthly income of R5 001 to R10 000 had both positive and negative influences on water-use efficiency, improving forecasting and improving insurance scheme. Technical measures and improving forecasting were positively related, while water-use efficiency and improving insurance scheme were negatively related. These results show that an income of between R5 001 and R10 000 is important for adopting water-use efficiency and improving insurance scheme as a coping strategies. A monthly income of between R10 001 and R20 000 had a positive influence on technical measures, water-use efficiency, improving insurance scheme, economic instruments and improving forecasting. This is consistent with the study by Alam (2015), who found that a unit increase in household income significantly increases the probability of adaptation of a coping strategy. Of all the variables that were significant, water-use efficiency and improving insurance scheme were negatively correlated and the others were positively correlated. Therefore, this implies that farmers with a monthly income of R10 001 to R20 000 are less likely to adapt to improving insurance scheme and water-use efficiency as a coping strategy and more likely to adapt to improving forecasting, economic instruments and technical measures as coping strategies. It therefore shows that it costs money for farmers to be able to adapt to certain coping strategies. This finding is consistent with the study by Mdungela (2015), who found that income will help farmers adapt to more than one coping strategy.

The ***human capital index*** was found to be statistically significant and to have a positive influence on technical measures as a coping strategy. This implies that human capital factors will influence the farmers to adapt technical measures as a coping strategy.

The ***economic capital index*** *was* found to be statistically significant and to have a positive influence on water-use efficiency and a negative influence on economic instruments as coping strategies. This implies that economic factors will contribute to the farmers' choice of adopting water-use efficiency as a coping strategy.

The ***institutional capital index*** was found to be statistically significant and to have a negative influence on improving forecasting as coping strategy. The negative sign of the estimated coefficient for improving forecasting implies that farmers are less likely to adapt improving forecasting as a coping strategy.

The ***natural capital index***was found to be statistically significant and to have a positive influence on economic instruments and improving insurance scheme. This implies that farmers are more likely to adopt economic instruments, improving insurance scheme and water-use efficiency as coping strategies.

The fitted variable (**constant**) was found to be statistically significant and to have a positive influence on improving insurance scheme and water-use efficiency as coping strategies. This implies that the farmers are more likely to adapt to water-use efficiency and improving insurance scheme.

4.5 Chapter summary

The farmer's perceptions of drought were found to be important in understanding drought awareness. The survey data revealed that the majority of the farmers perceived drought as a natural disaster (89%), while some perceived it as a manmade disaster (46.5%). Farmers perceived drought to be a natural disaster that is going to be more frequent in the coming years (68%). Furthermore, the smallholder farmers perceived water pans drying (50.2%) as the most important/severe effect of drought, with lack of livestock food and drinking water (47.5%) being the second most severe effect. Farmers' level of vulnerability to drought was found to be more in the human capital index (3.13) compared to other capitals. Socio-economic factors and vulnerability found males to be more vulnerable compared to females; farmers with no formal education are more vulnerable; less-skilled farmers were found to be more vulnerable; and those with less monthly income (less than R2 000 per month)were more vulnerable. The analysis also explained the different coping strategies, which found rainwater harvesting (27.2%) to be the most used coping strategy during the 2015/2016 drought. A total of 26.9% of the farmers implemented water-use restriction as an adaptation measure.

The finding from the analysis show that the multinomial logit model is appropriate for this kind of analysis. The analysis showed that characteristics such as age, gender, drought frequency, education, monthly income and farming skills are the most important contributors to farmers' choice of effective coping/adaptation strategy. The added capitals (social, human, economic, institutional, natural and political) positively and negatively influence farmers' choice of adaptation strategies.

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Background information

Drought is one of the most disastrous climate-related threats in the world, with impacts on agriculture, environment, infrastructure, and socioeconomic activities (Moeletsi and Walker 2016).According to the South African Government Gazette (2005).Drought is a major feature of the climate of Southern Africa and often has a devastating impact. Agriculture is a major social and economic sector in the Southern African Development Community (SADC) region, contributing between 4% and 27%of the region's gross domestic product (GDP) (Department of Environmental Affairs 2014).The most widely used method of agricultural farming in Sub-Saharan Africa is smallholder farming, and the majority of the rural poor depend on it for survival (Department of Agriculture, Forestry and Fisheries 2010). The year 2015 was officially declared the driest year in South Africa since 1904 (South Africa Weather Service, 2015). The resource-poor farmers whose productivity is highly threatened by frequent droughts are the people who are affected the most (Reason et al. 2005;Zvomuya 2007). Small scale-farmers in the Free State rural areas are often overwhelmed with interrelated and complex problems that they have to deal with on a daily basis and adaptation mechanisms they need in order to survive (Below et al. 2007).

5.2 Problem statement

During drought periods and beyond, smallholder farmers in Thaba 'Nchu are often left without their livelihood and investment in agriculture. Smallholder farmers cannot manage or cope with drought without external influence in terms of assistance or relief packages from governmental and non-governmental agencies (South African Government Gazette 2005). The problem is that vulnerability is not accounted for and smallholder farmers are the ones who are more affected and vulnerable during drought occurrences, since they depend on agriculture for their livelihood. Most of the studies done in the Free State province have not looked at how the livelihood capitals enhance livelihood outcomes, including reducing the vulnerability of smallholder farmers to drought. The main objective of this study was to understand smallholder farmers' perceptions and coping strategies to drought in Thaba

‘Nchuin the Free State province of South Africa. The main objective was addressed through the completion of four sub-objectives: firstly, by determining farmers’ perceptions of drought based on the knowledge they have on agriculture; secondly, determining smallholder farmers’ levels of vulnerability to drought using their access to capital or assets; thirdly, identifying the current adaptation and coping strategies used by smallholder farmers in Thaba ‘Nchu; and lastly, determining factors influencing the choice of adaptation strategies in order to know the extent to which farmers’ levels of vulnerability affect theirchoice of coping or adaptation strategies during drought.

5.3 Study area and data collection

The study was carried out in Thaba ‘Nchu, which is located 67 km east of Bloemfontein and has a scattered development pattern, with 37 villages surrounding the urban centre, some as far as 35 kilometres from the closest urban centre and 12km further to the east of Botshabelo and used to be part of the Bophuthatswana “Bantustan”. It comprises a large area of rural settlements on former trusts lands. The area is characterised by vast stretches of communal grazing that surround the urban centre. Thaba ‘Nchu agriculture comprises crop production, animal production, dairy farming, fruit production and agro-processing.

The data for this study was collected using structured questionnaires. The target respondents were smallholder farmers in Thaba ‘Nchu. The reason why Thaba ‘Nchu was selected as the study area is because it has a large number of smallholder farmers in the district municipality. A total of 301 farmers were interviewed, selected from 14 villages. The smallholder farmers were randomly selected for interviews.

5.4 Characteristics of the respondents

The survey for the study showed that, among the 301 farmers interviewed in Thaba ‘Nchu, the majority were males (55.1%). There was also an indication that, although female smallholder farmers are not a majority, there is an increase in the number of female farmers. The age of the youngest smallholder farmer was 19 years, while the oldest was 91 years old. On average, smallholder farmers in Thaba ‘Nchuhave 19 years of farming experience, withone year being the minimum duration of farming experience and 74 years being the maximum. There was an average of four people per household amongst the smallholder farmers. The educational level among the smallholder farmers shows that they have some education, with the majority of the farmers having attained primary (37.9%) and secondary (42.9%) education. The survey data indicate that the majority of the smallholder farmers were married (44.9%). Furthermore, the survey data indicate that the majority of farmers in Thaba 'Nchu depend largely on social grants and earn an average monthly income of less than R 2000 (81.7%), which leaves only a small number of farmers earning anything above R5 000. The majority of the smallholder farmers in Thaba 'Nchu do not have access to climate information (59.5%), meaning that they do not receive early warnings ofdrought periods. However, more farmers revealed that they were more aware (67.8%) of drought frequency compared to those who were less aware (4.4%). Lastly, the majority of the farmers in Thaba 'Nchu do not have access to extension services (80.7%), which makes them even more vulnerable to drought.

5.5 Results and discussion

The smallholder farmers in Thaba 'Nchu perceived the nature of drought to be a natural disaster. They perceived thatdroughts willbecome more frequent in the coming years. Thefarmers in Thaba 'Nchu had different perceptions of the effects of drought, with the most severe being perceived aswater pans drying, followed by livestock migration. Furthermore, farmers' vulnerability to drought was found to be more in the human capital index, which comprises age, gender, education, farming experience and farming skills. Total vulnerability of gender shows that males are more vulnerable, while total vulnerability of education shows that farmers with no formal education are more vulnerable to drought. Total vulnerability of skills to drought shows that farmers with no farming skills are more vulnerable to drought, as are single farmers and those with a monthly income of less than R2 000 per month. Lastly, different drought adaptation measures were used, and the most used adaptation measure in Thaba 'Nchu was water-use restriction.

The results of the analysis of the determinants of the choice of effective adaptation strategy using the multinomial logit estimates show that water-use restriction as a coping strategy is negatively influenced by the gender of the smallholder farmers. The conclusion from the results is that gender is an important variable affecting adaptation decisions at the farm level. The age of the farmers in Thaba 'Nchu positively influenced water-use restriction and economic instruments as a coping strategy. The conclusion from this finding is that older smallholder farmers are more likely to adopt water-use restriction and economic instruments as coping strategies. Seasonal farming has a negative influence on improving insurance scheme as a coping strategy, therefore it is concluded that it hinders the chance of smallholder farmers adapting. Frequency of drought positively influences smallholder farmers' choice of adopting improving forecasting, water-use efficiency and economic instruments as coping strategies. It is concluded that the coping strategies (improving forecasting, water use efficiency and economic instruments) have the potential to improve the chance of smallholder farmers' adaptation, while technical measures as a coping strategy is positively influenced by the farming skills of the farmers. Therefore, it is concluded that farming skills have the potential to influence farmers to adapt technical measures as a coping strategy. Secondary education negatively influences technical measures as a coping strategy, while primary, secondary and tertiary education positively influences technical measures, water-use efficiency, economic instruments, water-use restriction, improving forecasting and improving insurance schemes as coping strategies. The conclusion from this finding is that any form of education influences coping strategies. Marital status negatively influences water-use restriction as coping strategy. It is concluded that marital status hinders the adoption of water-use restriction as a coping strategy. Monthly incomes (R2 000 to R5 000, R5 001 to R10 000, R10 001 to R20 000) have a positive influence on improving forecasting as a coping strategy and a negative influence on technical measures, water-use efficiency, economic instruments, water-use restriction and improving insurance schemes as coping strategies. It is concluded that income can hinder farmers from adapting and also influence adaptation. Furthermore, the human capital index positively influences technical measures as coping strategy. It is concluded that human capital factors will influence farmers' decisions to adapt technical measures. The economic capital index positively influences water-use efficiency and economic instruments as coping strategies, therefore it is concluded that human capital factors will influence farmers' decisions to adapt water-use efficiency and economic instruments as coping strategies. The institutional capital index negatively influences improving forecasting as a coping strategy. It is therefore concluded that institutional capital factors will hinder the adoption of improving forecasting as a coping strategy. Lastly, the natural capital index positively influences improving insurance scheme and economic instruments as coping strategies, therefore it is concluded that the natural capital factors will influence farmers to adopt improving insurance scheme and economic instruments as coping strategies.

5.6 Conclusions

It can be concluded from the results that farmers in Thaba ‘Nchu are affected by drought. Therefore, it means that farmers have the potential to prepare and apply certain coping strategies in order to cope better with the recurring drought.

The first objective was to determine farmers’ perceptions of drought in relation to their experience. The respondents perceived drought as both a manmade and natural disaster and their reasons were that even though it is a natural disaster, human beings still contribute towards drought. Most households perceived an increase in the frequency of droughts in the future due to the fact that there has been so much loss of livestock and crops in the research area. The effects of drought differ according to each respondent’s personal experience with drought, because although most of the households are livestock farmers, there are those who are crop farmers and they perceive drought effects differently. The conclusion is that different households perceive drought, drought frequency and drought effects differently.

The second objective was to determine smallholder farmers’ level of vulnerability to drought using their access to capital or assets during drought. Different capitals were used to measure/see how much they contributed towards the vulnerability of the respondents to drought, with the emphasis mainly being on social and economic vulnerability. The findings of the research reveal that human capital vulnerability of smallholder farmers to drought in Thaba ‘Nchu is very high compared to economic and social vulnerability. Influences such as age, gender and marital status contributed greatly towards human capital vulnerability. All the identified indicators were analysed and their contribution to vulnerability to drought was discussed. The conclusion is that different indicators contribute differently to drought vulnerability. The respondents from the study area are more vulnerable to drought because they do not have enough resources/help to assist them during drought periods.

The third and fourth objectives were to determine the different coping strategies. MNL was used to measure the variables that are coefficients towards contributing to certain coping strategies. The majority of the respondents used water-use restriction as a coping strategy during drought periods. There are several reasons for this, such as the resources available, the effective coping strategy for that specific location/area, and the socio-economic status of the respondents. Government’s inadequate contribution to drought risk reduction, the age of the respondents, the monthly income of each household, and the inequality of decision-making powers between male and female farmers were also found to contribute greatly to choosing an effective adaptation strategy. Government was perceived as being active mainly in response. Government support was referred to as inefficient and not accessible to everyone. The conclusion is that there is still much that needs to be done in order to help farmers cope with drought in the future.

5.7 Recommendations

Based on the findings of this dissertation, a number of recommendations can be made. This section sets out recommendations for policymakers that might contribute towards uplifting the livelihood of smallholder farmers in Thaba ‘Nchu. The following recommendations are proposed:

Farmers in Thaba ‘Nchuhave not implemented many coping strategies; however, they do consider a number of them to be effective/necessary. Policymakers should aim at improving/implementing those coping strategies that the farmers deem necessary in order for farmers to have more coping strategy options in the future. The Department of Agriculture should consider training smallholder farmers and providing resources to farmers that will enhance their knowledge about other coping strategies that are available for use.

Farming skills have been found to significantly influence responsiveness to drought, as was education. When farmers are educated and skilled, they stand a better chance of coping better with drought, therefore it is recommended that policymakers should ensure that a government programme is implemented in order to help farmers with off-farm training that will assist them to prepare for drought and help them with decision-making processes during periods of drought.

Monthly income has been found to significantly influence responsiveness to drought. The majority of farmers in Thaba ‘Nchu earn less than R2 000 per month, therefore policymakers should improve the policy of government drought-relief benefits. The government and the Department of Agriculture must provide financial aid to smallholder farmers and should consider collaborating with donor agencies and NGOs to help with financial aid, especially for smallholder farmers in rural areas.

Most farmers in Thaba ‘Nchu depend on agriculture for a living and they do not all receive help from the government. A policy should be introducedto ensure that all farmers receive help during times of drought. There are a limited number of extension officers in the area; therefore more extension officers need to be trained so that all the farmers in the area are able to get help. It is recommended that research must be conducted with the Department of Agriculture to see how it is helping farmers in times of drought. The research needs to look at what government officials are doing in order to reduce vulnerability in the incidence of drought.

REFERENCES

Abou-Hadid, A.F. 2006. Assessment of impacts, adaptation and vulnerability to climate change in North Africa: Food production and water resources. Washington, DC.AIACC Report, 2-15.

Acquah-de Graft, H. 2011. Farmers' perceptions and adaptation to climate change: A willingness to pay analysis. *Journal of Sustainable Development in Africa* 13(5): 150–61.

Acquah-de Graft, H., and E. Onumah. 2011. Farmers' perceptions and adaptations to climate change: An estimation of willingness to pay. *Agris* 3(4):31–9.

Adesina, A.A., and M.M. Zinnah. 1993. Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural Economics* 9(4): 297–311.

Adato, M., and R. Meinzen-Dick. 2002. Assessing the impact of agricultural research on poverty using the sustainable livelihoods framework. Food Consumption and Nutrition Division (FCND) Paper 128. International Food Policy Research Institute, Washington, D.C. 1-57.

Adger, W.N. 1998. Indicators of social and economic vulnerability to climate change in Vietnam', Centre for Social and Economic Research, Global Environment. University of East Anglia. p. 42.

Adger, W.N., N.W. Arnell, and E.L. Tompkins. 2005. Successful adaptation to climate change across scales. *Global Environmental Change* 15(2): 77–86.

Adu, D.T., J.K.M. Kuwornu, H. Anim-Somuahand N. Sasaki. 2018. Application of livelihood vulnerability index in assessing smallholder maize farming households' vulnerability to climate change in Brong-Ahafo region of Ghana. *Kasetsart Journal of Social Sciences* 39(1): 22–32.

Agri SA. 2016. Drought 2016: The latest from Agri SA. Available online: https://www.agrisa.co.za/drought-2015-the-ins-and-outs/?lang=za (Accessed 20 November 2016).

Akpalu, D.A. 2005.Response scenarios of households to drought-driven food shortage in a semi-arid area in South Africa. Master's thesis, University of the Witwatersrand.

Alam, M.,S.S.,Alam, A., Rahman, M.R.,Uzzaman M. Rashid and G. Rabbani. 2009. Risks, vulnerability and adaptation in Bangladesh. Human Devel- opment Report 2007/08, Human Development Report Office Occa- sional Paper, 2007/13.

Alam, K. 2015. Farmers' adaptation to water scarcity in drought-prone environments: A case study of Rajshahi District, Bangladesh. *Agricultural Water Management*148: 196–206.

American Meteorological Society. 2006. A Review of Drought in the Middle East and Southwest Asia. Available online: https://journals.ametsoc.org/toc/apme/current (Accessed on 5 May 2016).

Anderson, J.R., and J. Thampallai. 1990. *Soil conservation in developing countries. Project and policy intervention*. Washington, DC: World Bank.

Anim, F. 1999. A note on the adoption of soil conservation measures in the Northern Province of South Africa. *Journal of Agricultural Economics* 50(2): 336–450.

Anley, Y., A.Bogale, and A.Haile-Gabriel, 2007. Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo district, Western Ethiopia. *Land Degradation and Development* 18(3): 289–302.

Apata T.G., K.D. Samuel, and A.O. Adeola. 2009. Analysis of climate change perception and adaptation among arable food crop farmers in South Western Nigeria. International Association of Agricultural Economists' 2009 Conference. Beijing, China, August 16-22, 1–15.

Araya, B., and J.A. Adjaye. 2001. Adoption of farm level soil conservation practices in Eritrea. *Indian Journal of Agricultural Economics* 56: 239–52.

Asfaw, A., and A. Admassie. 2004. The role of education in the adoption of chemical fertilizer under different socio-economic environments in Kenya. *Agricultural Economics* 30: 215–28.

Ashraf, M., and J.K. Routray. 2013. Perception andunderstanding of drought and coping strategies of farming households in north-west Balochistan. *International Journal of Disaster*

*Risk Reduction*5: 49–60.

Austin, W.D.2008. Drought in South Africa: Lessons lost and/or learnt from 1990 to 2005. MSc dissertation, University of the Witwatersrand.

Axelrod, L., and D. Lehman.1993. Responding to environmental concerns: Whatfactorsguideindividual action?*Journal of Environmental Psychology* 13(2):149–59.

Backeberg, G.R., and M.F. Viljoen. 2003. Drought management in South Africa. Paper presented at a workshop of the ICID Working Group on “Irrigation under drought and water scarcity', August 13-14, in Tehran, IR of Iran.

Baethgen, W.E., H. Meinke, and A. Gimene. 2003. Adaptation of agricultural production systems to climate variability and climate change: Lessons learned and proposed research approach. Insights and Tools for Adaptation: Learning from Climate Variability, Washington, DC: 1-10

Baidu-Forson, G, 1999. Factors influencing adoption of land-enhancing technology in the Sahel: Lessons from a case study in Niger. *Agricultural Economics* 20: 231–39.

Bang, S.K., and K. Sitango. 2003. Indigenous drought coping strategies and risk management against El Nino in Papua New Guinea. CGPRT Centre Working Paper No.74. http://ageconsearch.umn.edu/handle/32687 (accessed: May 6, 2016).

Bayard, B., C.M.,Jolly. and D.A. Shannon. 2007. The economics of adoption and management of alley cropping in Haiti, *Journal of environmental management*, 84: 62 – 70.

Bekele, W., and L. Drake. 2003. Soil and water conservation decision behaviour of subsistence farmers in the Eastern Highlands of Ethiopia: A case study of the Hunde-Lafto area, *Ecological Economics* 46: 437–51.

Below, T., A. Artner, R. Siebert, and S. Sieber. 2010. Micro-level practices to adapt to climate change for African small-scale farmers: A review of selected literature. IFPRI Discussion Paper 00953. International Food Policy Research Institute (IFPRI), Washington DC.

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

Benson C. and E. Clay, 1998. The Impact of Drought on sub-Saharan African Economies. Technical Paper No. 401. World Bank, Washington, DC: 95.

Birungi, P.B. 2007. The linkages between land degradation, poverty and social capital in Uganda. PhD thesis, University of Pretoria.

Blaikie, P., I.D. Cannon, and B. Wisner. 1994. *At risk: Natural hazards, people's vulnerability and disasters'* London: Routledge.

Boko, M., A. Niang, A. Nyong, C. Vogel, M. Githeko, and M. Mednay.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. 433–67.

Botai, C.M., J.O. Botai, L.C. Dlamini, N.S. Zwane, and E. Phaduli. 2016. Characteristics of droughts in South Africa: A case study of Free State and North West provinces. *Water* 8(10): 439.

Briguglio, L., G., Cordina, NFarrugia. and S.Vella 2009. Economic vulnerability and resilience: Concepts and measurements, *Oxford Development Studies*, 37(30): 229–247.

Bruin, K. 2011. An economic analysis of adaptation to climate change under uncertainty. Doctoral dissertation, University of Wageningen.

Bryan, 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(4): 413–26.

Bryan, E., C. Ringler, B. Okoba, C. Roncoli, S. Silvestri, and M. Herrero. 2013. Adapting agriculture to climate change in Kenya: Household strategies and determinant. *Journal of Environmental Management*114: 26–35.

Bryant, C.R., B. Smit, M. Brklacich, T. Johnston, J. Smithers, Q. Chiotti, and B. Singh. 2000. Adaptation in Canadian agriculture to climatic variability and change. *Climatic Change* 45:181–201.

Brynard, P.A., and S.X. Hanekom. 2006. *Introduction to research in management related fields*. 2nd ed. Pretoria: Van Schaik.

Bureau for Food and Agricultural Policy. 2015. Policy brief on the 2015/2016 drought.*Integrated Value Information System*: 4–17.

Burton, M., D. Rigby, and T. Young. 1998. Analysis of the determinants of adoption of organic horticultural techniques in the UK. *Journal of Agricultural Economics* 50: 47–63.

Bwambale, N. 2015. Farmers' knowledge, perceptions, and socioeconomic factors influencing decision making for integrated soil fertility management practices in Masaka and Rakai Districts, Central Uganda. Master's thesis, Iowa State University.

Chabane, N. 2002. 2002. An evaluation of the influences on price and production in the maize market following liberalisation. Trade & Industrial Policy Strategies (TIPS), Annual Forum Papers, Pretoria.

Chambers, R. and G.R. Conway. 1992. Sustainable rural livelihoods: Practical concepts for the 21stcentury. IDS Discussion Paper No. 296. IDS, Brighton, UK.

CIMMYT (International Maize and Wheat Improvement Center). 1993. The Adop- tion of Agricultural Technology:AGuide for Survey Design. Economics Program, Mexico City, Mexico.

Clay, D., T. Reardon, and J. Kangasniemi. 1998. Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility. *Economic Development and Cultural Change* 46(2): 351–78.

Climate-Data. 2017. Annual climate data for the Free State Province. Available online: www.climatedata.org (Accessed May 2, 2018).

Cobb, C. and Rixford, C. 1998. Lessons Learned from the History of Social Indicators, Redefining Progress, San Francisco.

Cohen, D., and L. Prusak. 2001. I*n good company. How social capital makes organizations work*. Boston, Ma: Harvard Business School Press.

Cooper, P.J.M., J. Dimes, K.P.C. Rao, B. Shapiro, B. Shiferaw and B. Twomlow. 2006. Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change?*Agriculture, Ecosystems and Environment* 126(1–2): 24–35.

Cordina, G. 2004. Economic vulnerability and economic growth: Some results from a neo-classical growth modelling approach. *Journal of Economic Development* 21(2): 21–39.

Coulibaly, J.Y., G.A. Gbetibouo, G. Kundhlande, G.W. Sileshi, and T.L. Beedy. 2015. Responding to crop failure: Understanding farmers' coping strategies in Southern Malawi.*Sustainability*7 (2): 1620–36.

Cox, J. 1996. *How to build the best questionnaires in the field of education*. Los Angeles,California: Corwin Press.

Croppenstedt, A., M. Demeke, and M. Meschi.2003. Technology adoption in the presence of constraints: The case of fertilizer demand in Ethiopia. *Review of Development Economics* 7: 58–70.

Cutter, S.L. 1996. Vulnerability to environmental hazards. *Progress in Human Geography* 20: 29–39.

Cutter, S.L., B.J. Boruff, and W.L. Shirley. 2003. Social vulnerability to environmental hazards.*Social Science Quarterly* 84(2): 242–61.

Demeke, A.B., and M. Zeller. 2012. Weather risk and household participation in off-farm activities in rural Ethiopia. *Quarterly Journal of International Agriculture* 51: 1–20.Department of Agriculture, Forestry and Fisheries. 2010. *Progress report by the Department of Agriculture, Forestry and Fisheries on disaster risk management*. Pretoria: Government Printer.

Department of Agriculture, Forestry and Fisheries. 2011. Agricultural productivity in South Africa: literature review. Available online: http://www.daff.gov.za/docs/GenReports/AgricProductivity.pdf (Accessed on 30 March 2016).

Department of Agriculture and Rural Development. 2011. Annual report 2011/12. Available

online:
http://www.gauteng.gov.za/Document%20Library/Agriculture%20and%20Rural%20Development/Annual%20Report%202011%20-%202012.pdf (Accessed on 13 February 2017).

Department of Environmental Affairs (DEA). 2014. National Climate Change Response Green Paper 2010, Pretoria.

Department of Environmental Affairs and Tourism. 2004. *National Climate ChangeResponse Strategy*. http://unfccc.int/files/meetings/seminar/application/pdf (Accessed September 28, 2017).

Deressa, T.T., R.M. Hassan, C. Ringler, T. Alemu, and M. Yesuf. 2008. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change* 19(2): 248–55.

Desalegn, C.E., M.S. Babel, A.D. Gupta, B.A. Seleshi, and D. Merrey. 2006. Farmers' perception of water management under drought conditions in the upper Awash Basin, Ethiopia. *International Journal of Water Resources Development* 22(4): 589–602.

Dessai, S., and C. Sims. 2010. Public perception of drought and climate change in Southeast England. *Environmental Hazards* 9(4): 340–57.

De Wit, M. 2006. The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. CEEPA, University of Pretoria.

DFID (Department for International Development). 1999. *Sustainable livelihood guidance sheets*. London: DFID Publishers.

DFID (2000): Sustainable Livelihoods Guidance Sheets. Department for International Development.http://www.livelihoods.org/info/info_guidancesheets.html(Accessed 15 October 2017).

Dhaka, B.L., K. Chayal, and M.K. Poonia. 2010. Analysis of farmers' perception and adaptation strategies to climate change. *Libyan Agriculture Research Centre Journal International:* 388–90.

Diggs, D.M. 1991. Droughtexperience and perception of climatic change among Great Plains farmers. *Great Plains Research*1(1): 114–32.

Dolisca, F., R.D. Carter, J.M. McDaniel, D.A. Shannon, and C.M. Jolly. 2006. Factors influencing farmers' participation in forestry management programs: A case study from Haiti. *Forest Ecology and Management* 236:324–31.

Eriksen, S, and J.A. Silva. 2009. The vulnerability context of a savanna area in Mozambique: Household drought coping strategies and response to economic change. *Environmental Science & Policy* 12: 33–52.

Ervin, C.A., and D.E. Ervin. 1982. Factors affecting the use of soil conservation practices: Hypotheses, evidence, and policy implications. Land Economics 58(3): 277–92.

Featherstone, A.M., and B.K. Goodwin. 1993. Factors influencing a farmer's decision to invest in long-term conservation improvements. *Land Economics* 69: 67–81.

Feder, G., R.E. Just, and D. Zilberman. 1985. Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change* 33: 255–98.

Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, and M.D. Mastrandrea.2014. *Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Climate Change 2014: Impacts, Adaptation, and Vulnerability.1132.

Fine, B. 1997. Entitlement failure? Development and Change. Institute of Social Studies 1997,(28): 617-647.

Food Pricing Monitoring Committee. 2003. Available online: https://pmg.org.za/committee-meeting/5259/ (Accessed September 2, 2016).

Fosu-Mensah, B., P. Vlek, and M. Manschadi. 2010. Farmers' perceptions and adaptations to climate change: A case study of Sekyedumase District in Ghana. Paper presented at the World Food Systems Conference in Tropentag, Zurich, September.

Franzel, S. 1999. Socioeconomic factors affecting the adoption potential of improved tree fallows in Africa.*Agroforestry Systems* 47(1-3): 305–21.

Free State Development Corporation. 2011. About the Free State Agriculture. Available online: http://www.mapsez.co.za/about-the-free-state/agriculture(Accessed 3 October 2016).

Gandure, S., S. Walker, and J.J. Botha. 2013. Farmers' perceptions of adaptation to climate change and water stress in a South African rural community. *Environmental Development*5(1): 39–53.

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. IFPRI, Washington DC.

Kenneth C. Dagel. 1997. Defining Drought in Marginal Areas: The Role of Perception, The Professional Geographer (Geogr), 49(2): 192-202.

Ghadim, A.K.A., D.J. Pannell, and M.P. Burton. 2005. Risk, uncertainty, and learning in adoption of a crop innovation. *Agricultural Economics* 33(1): 1–9.

Gidey Gebrehiwot, T., T.G. Gidey, and A. van der Veen. 2013. Climate change vulnerability in Ethiopia: Disaggregation of Tigray Region. *Journal of Eastern African Studies* 7(4): 607–29.

Githeko, A.K. 2006. The effects of climate change on infectious dis- eases of animals. UK Foresight Project, Infectious Diseases: Preparing for the Future. Office of Science and Innovation, London: 35.

Glantz, M.H., M. Bestil, and K. Crandall. 1997. *Food security in Southern Africa – Assessing the use and value of ENSO information*. Boulder: National Center for Atmospheric Reseach.

Gould, B.W., W.E. Saupe, and R.M. Klemme. 1989. Conservation tillage: The role of farm and operator characteristics and the perception of erosion. *Land Economics*65: 167–82.

Greene, W.H.2003. *Econometric analysis*. 5th ed. New Jersey: Prentice Hall.

Greiner, R., L. Patterson, and O. Miller. 2009. Motivations, risk perceptions and adoption of conservation practices by farmers. *Agricultural Systems* 99(2): 86–104.

Groenewald, J. and L. Nieuwoudt.2003. Demands on and challenges for South African agriculture. The challenge of change: agriculture land and the South African economy. Pietermaritzburg: University of Natal Press: pp.61-75.I

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.

Guillaumont, P. 1999. On the economic vulnerability of low income countries. Mimeo, CERDI-CNRS, Université d'Auvergne, France.

Gwimbi, P. 2009. Cotton farmers' vulnerability to climate change in Gokwe district (Zimbabwe): Impact and influencing factors. Jàmbá: *Journal of Disaster Risk Studies*2(2).https://doi.org/10.4102/jamba.v2i2.17

Habiba, U., R. Shaw, and Y. Takeuchi. 2012. Farmer's perception and adaptation practices to cope with drought: Perspectives from Northwestern Bangladesh. *International Journal of Disaster Risk Reduction*1(1):72–84.

Hahn, M.B., A.M. Riederer, and S.O. Foster. 2009. The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change – A case study in Mozambique. *Global Environmental Change* 19(1): 74–88.

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(1): 83–104.

Hayman, P. and Cox, P. 2003.Perceptions of drought risk: The farmer, the scientist and thepolicy economist'. In: Botterill, L.C. and Fisher, M. (eds.), Beyond drought: People, policy and perspectives. Australia: CSIRO Publishing: 153-173.

Hazelton, D.G., I. Pearson, and A.W. Kariuki. 1994. Development of drought response policy options for cost-effective provision of water supply to rural communities subject to recurring droughts. Report to the Water Research Commission by the Development Services and Technology Programme Division of Water Technology CSIR. Germany, Berlin: Inter-Research.

Hermann W. 2009. Climate risk and farming systems in rural Cameroon. Germany: Institute of Development and Agricultural Economics, University of Hannover; 21–4.

Hisali, E., P. Birungi, and F. Buyinza. 2011. Adaptation to climate change in Uganda: Evidence from micro level data. *Global Environmental Change* 21: 1245–61.

Holm, J.D. and R.G. Morgan. 1985. Coping with drought in Botswana: An African success. Journal of modern African studies, 23(3): 463-482.

Hopkins, C.D., and R.L. Antes.1990. *Educational research: A structure for enquiry*. 3rd ed. Illinois: Peacock Publishers.

International Fund for Agricultural Development. IFAD. 2009. Climate change impacts in the Asia/pacific region. The Stern Review and IPCC 4th Assessment.

Igoden, C., P. Ohoji, and J. Ekpare. 1990. Factors associated with the adoption of recommended practices for maize production in the Lake Basin of Nigeria. *Agricultural Administration and Extension* 29(2): 149–56.

Ishaya, S., and I.B. Abaje. 2008. Indigenous people's perception on climate change and adaptation strategies in Jema'a local government area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning* 1(8): 138–43.

Jones, J.W. 2003. Agricultural responses to climate variability and climate change. Paper presented at the Climate Adaptation.net Conference Insights and Tools for Adaptation: Learning from Climate Variability, November 18-20, Washington, DC.

Jordaan,A.J. 2012. Drought risk reductionintheNorthernCapeProvince,SouthAfrica. PhD thesis, University of the Free State.

Jordaan, A.J., D. Sakulski, and A.D. Jordaan. 2013. Interdisciplinary drought risk assessment for agriculture: The case of communal farmers in the Northern Cape Province, South Africa. *South African Journal of Agricultural Extension*41(1):1–16.

Jordan, A.J and B. Adoko. 2014. Karamoja Drought Risk Assessment: Is Drought to Blame for Chronic Food Insecurity? International Documentation. International Rescue Committee, Kampala, Uganda.

Juana, J.S., K. Kahaka, and F.N. Okurut. 2013. Farmers' perceptions and adaptations to climate change in Sub-Saharan Africa: A synthesis of empirical studies and implications for public policy in African agriculture. *Journal of Agricultural Science* 5(4): 121–35.

Kamruzzaman, M. 2015. Farmers' perceptions on climate change: A step toward climate change adaptation in Sylhet Hilly Region. *Universal Journal of Agricultural Research* 3: 53–8.

Kandlinkar, M., and J. Risbey.2000. Agricultural impacts of climate change: If adaptation is the answer, what is the question? *Climatic Change* 45: 529–39.

Kebede, Y., K. Gunjal, and G. Coffin. 1990. Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga District, Shoa Province. *Agricultural Economics*4: 27–43.

Keeley, J. 2001. *Influencing policy processes for sustainable livelihoods: Strategies for change*.Brighton: Institute of Development Studies.

Keshavarz, M., H. Maleksaeidi, and E. Karami. 2017. Livelihood vulnerability to drought: A case of rural Iran. *International Journal of Disaster Risk Reduction*21(December): 223–30.

Kirkby, A.V. 1974. Individual and community response to rainfall variability in Oaxaca, Mexico. In *Natural hazards: Local, national, global*, ed. G.F. White.: 119–271.Taylor and Francis Ltd, Mexico.

Knowler, D., and B. Bradshaw. 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy* 32(1):25–48.

Knutsson, P. and M. Ostwald. 2006. A process-oriented sustainable livelihoods approach –A tool for increased understanding of vulnerability, adaptation and resilience. *Mitigation and Adaptation Strategies for Global Change*. https://doi.org/10.1007/s11027-006-4421-9 (Accessed on 23 January 2017).

Kollmair, M., and S.T. Gamper. 2002. The sustainable livelihoods approach. Input paper for the Integrated Training Course of NCCR North-South Aeschiried.

Krathwohl, D.R. 1993. *Methods of educational and social science research: An integrated approach*. New York: Longman/Addison Wesley Longman.

Krüger, F. 1999. Drought hazards and threatened livelihoods: Environmental perceptions in

Botswana. In*Coping with changing environments: Social dimensions of endangered ecosystems in the developing world*, ed. B. Lohnert and H. Geist: 175-190. Ashgate: Aldershot.

Kurukulasuriya, P., and R. Mendelsohn. 2006. A Ricardian analysis of the impact of climate change on African cropland. CEEPA Discussion Paper No. 8. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Kværner, J., G. Swensen, and L. Erikstad. 2006. Assessing environmental vulnerability in EIA – The content and context of the vulnerability concept in an alternative approach to standard EIA procedure. *Environmental Impact Assessment Review* 26(5): 511–27.

Lapar, M.L.A., and S. Pandely. 1999. Adoption of soil conservation: The case of Philippine uplands. *Agricultural Economics* 21: 241–56.

Leach, M., R.Mearns, and I.Scoones, 1997. Environmental Entitlements: A Framework for Understanding the Institutional Dynamics of Environmental Change. Discussion Paper 359, Institute of Development Studies, University of Sussex, Brighton, UK.

Legesse, B. and L. Drake. 2005. Determinants of smallholder farmers' perceptions of risk in the Eastern Highlands of Ethiopia. *Journal of Risk Research* 8(5): 383–416.

Legesse, B., Y. Ayele, and W. Bewket. 2012. Smallholder farmers' perception and adaptation to climate variability and climate change in Doba District, West Hararghe, Ethiopia. *Asian Journal of Empirical Research* 3(3): 251–61.

Lin, J. 1991.Education and innovation adoption in agriculture: Evidence from hybrid rice in China. *American Journal of Agricultural Economics* 73(3): 713–23.

Lorenzoni, I., and I. Langford.2005. Climate change now and in the future: A mixed methodological study of public perceptions in Norwich (UK). CSERGE Working Paper ECM 01-05. University of East Anglia, Norwich.

Maddison, D. 2006. The perception of and adaptation to climate change in Africa. Policy Research Working Paper No. 4308. World Bank, Washington DC.

Mahouna, A., R. Fadina, and D. Barjolle. 2018. Farmers' adaptation to climate change and their implications in the Zou Department of South Benin. *Environments* 5(1): 15.

Makgetla, N., and E. Watkinson. 2002. South Africa's food security crisis. Detailed report supporting a position paper tabled at NEDLAC Management Committee on 28 February.

Mamba, S.F. 2016. Factors influencing perception of climate variability and change among smallholder farmers in Swaziland. *Indian Journal of Nutrition* 3(2):1–7.

Mandleni, B., and F.D.K. Anim. 2007.Climate change awareness and decision on adaptation measures by livestock farmers. *Journal of Agricultural Science* 3(3). http://dx.doi.org/10.5539/jas.v3n3p258 (Accessed on 4 July 2016).

Mangala, B. 2008. Impact of integrated farming system on socio-economic status of Bharatiya Agroindustries Foundation (BAIF) beneficiary farmer. Master's thesis, University of Agricultural Sciences, Dharward, India.

Mangaung Metropolitan Municipality Draft Integrated Development Plan. 2017. Impact on farmers and the agricultural sector. Available online: http://www.thabomofutsanyana.gov.za/downloads/Final%20IDP%202014-15.pdf (Accessed on 15 November 2018). .

Maphalla L.T. and M.V.Salman.2012. Provincial report on education and training for agriculture and rural development: Free State province 2012. Free State: Department of Agriculture, Forestry and Fisheries.

Maraj, K. 2000. The role of governing bodies in the transformation of education in South Africa. PhD thesis, Rand Afrikaans University.

Mason, S.J., and P.D. Tyson. 2000. The occurrence and predictability of droughts over Southern Africa. In *Drought: A global assessment*, ed. D.A. Wilhite, 113–34. London: Routledge.

May, J., C. Rogerson, and A. Vaughan. 2000. Livelihoods and assets. In *Poverty and inequality in South Africa: Meeting the challenge*, ed. J. May, 229–58. Cape Town and London: David Phillip and Zed Press.

McCarthy, J.J., O. Canziani, N.A. Leary, D.J. Dokken, and K.S. White. 2001. *Climate change*

2001: Impacts, adaptation and vulnerability. IPCC Workshop Group, Cambridge: CambridgeUniversity Press.

Mdungela, N.M., Y.T. Bahta, and A.J. Jordaan. 2017. Farmer's choice of drought coping strategies to sustain productivity in the Eastern Cape Province of South Africa. Mdpi, 1(January): 79–89.

Meijer, S.S., D. Catacutan, O.C. Ajayi, G.W. Sileshi, and M. Nieuwenhuis. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International Journal of Agricultural Sustainability* 13(1): 40–54.

Mengistu, D.K. 2011. Farmers' perception and knowledge of climate change and their coping strategies to the related hazards: Case study from Adiha, central Tigray, Ethiopia. *Agricultural Sciences* 2(2): 138–45.

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): 804–16.

Michaels, C.2000. Information, perception, and action: What should ecological psychologists learn from Milner and Goodale (1995),*Ecological Psychology* 12(3): 241–58.

Moeletsi, M., and S. Walker. 2011. Assessment of agricultural drought using a simple water balance model in the Free State province of South Africa. *Theoretical and Applied Climatology* 108(3–4): 425–50.

Monnik, K. 2000. Role of Drought Early Warning Systems in South Africa`s Evolving Drought Policy. Available at
http://0 www.drought.unl.edu.innopac.up.ac.za/monitor/EWS/ch5_Monnik.pdf . (Accessed 3 July, 2017).

Montenegro, A., J. de Lima, J. Abrantes, and T. Santos. 2013. Impact of mulching on soil and water conservation in semiarid catchment: Simulated rainfall in the field and in the laboratory. *Journal for Land Management, Food and Environment* 64(3-4): 79-85.

Moranga, L.O. 2016. Analysis of factors influencing tomato farmers' willingness to adopt innovative timing approaches for management of climate change effects in Taita Taveta County, Kenya.MSc thesis, University of Nairobi.

Morse, S., N. McNamara, and M.Acholo, 2009. Sustainable livelihood approach: A critical analysis of theory and practice, geographical paper No. 189. http://www.reading.ac.uk:8081/web/FILES/geographyandenvironmentalscience/GP1 89.pdf (Accessed on 20 February 2016).

Msangi, J.P. 2004. Drought hazard and desertification management in the drylands of Southern Africa. *Environmental Monitoring and Assessment* 99:75–87.

Mudombi, G. 2011. Factors affecting perceptions and responsiveness to climate variability induced hazards. Master's dissertation, University of Zimbabwe.

Mueller, R.A.E., and H.G.P.Jansen. 1988. Farmer and farm concepts in measuring adoption lags. *Journal of Agricultural Economics* 39(1): 121–4.

Muttarak, R. and W. Lutz. 2014. Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change? *Ecology and society* 19(1): 42.

Mutekwa, V.T. 2009. Climate change impacts and adaptation in the agricultural sector: The case of smallholder farmers in Zimbabwe. *Journal of Sustainable Development in Africa* 11(2): 237–56.

Muyambo, F. 2014. Assessing social vulnerability to drought: case of communal farmers in O.R. Tambo District. Master's dissertation, University of the Free State.

Nair, R., M. Kumar, and V. Nair. 2009. Agroforestry as a strategy for carbon sequestration.*Journal of Plant Nutrition and Soil Science* 172(1): 10–23.

National Drought Mitigation Center (NDMC). 2006. *Understanding and defining drought*. National Drought Mitigation Center, University of Nebraska-Lincoln.http://drought.unl.edu/whatis/concept.htm. (Accessed April 27, 2016).

National Meteorological Services Agency, 2001. Adaptation to Climate Change in Ethiopia. Available online:

https://www.researchgate.net/publication/222015072_Adaptation_to_Climate_Change_in_Ethiopia_and_South_Africa_Options_and_Constraints (Accessed July 22 2017).

Ncube, B., J. S. Twomlow,Dimes, M. van Wijk, and K. Giller.2015.Productivity and residual benefits of grain legumes to sorghum under semi-arid conditions in Southern Zimbabwe', Unravelling the effects of water and nitrogen. *Field Crops Research:* 1-15.

Ndambiri, H., C. Ritho, S. Mbogoh, S. Ng'ang'a, E. Muiruri, P. Nyangweso, M. Kipsat, J. Ogada, P. Omboto, C. Kefa, P. Kubowon,and F. Cherotwo. 2012. Assessment offarmers' adaptation to the effects of climate change in Kenya: The case of KyusoDistrict.*Journal of Economics and Sustainable Development* 3(12): 52–60.

Ndhleve, S., M.D.V. Nakim, and B. Longo-Mbenza. 2017. Impacts of supplemental irrigation as a climate change adaptation strategy for maize production: A case of the Eastern Cape Province of South Africa. *Water SA* 43(2): 222.

Ngaka, M.J. 2012. Drought preparedness, impact and response: A case of the Eastern Cape and Free State provinces of South Africa. *Journal of Disaster Risk Studies* 4(1): 1–10.

Nkonya, E., J. Pender, C. Kaizzi, E. Kato, and S. Mugarura.2005. Policy options for increasing crop productivity and reducing soil nutrient depletion and poverty in Uganda.EPTD Paper No. 134.International Food Policy Research Institute (IFPRI), Washington DC.

NOAA, 2006. An Experiment in the Application of Climate Forecasts: NOAA- OGP Activities Related to the 1997–98 El Niño Event. Office of Global Programs, National Oceanic and Atmospheric Administration, Silver Spring, MD, USA.

Norris, E., and S. Batie. 1987. Virginia farmers' soil conversation decisions: An application of tobit analysis. *Southern Journal of Agricultural Economics* 19(1): 173–86.

Norton. S., A. Wandersman. and C. Goldman. 1993. Perceived costs and benefits of membership in a self-help group: comparisons of members and nonmembers of the alliance for the mentally ill. Community Mental Health, in press.

Nowakowski, J.J. 2002. Variation of morphometric parameters within the Savi's warbler (Locustella luscinioides) population in eastern Poland. Ring: 24, 49.

Nyam, B.Y.S. 2017. A metafrontier analysis of sheep production in the N8 development corridor. Master's dissertation, University of the Free State.

Nyanga, P.H., F.H. Johnsen, J.B. Aune, and T.H. Kalinda. 2011. Smallholder farmers' perceptions of climate change and conservation agriculture: Evidence from Zambia. *Journal of Sustainable Development* 4(4): 73–85.

Nyangena, W. 2007. Social determinants of soil and water conservation in rural Kenya. *Environment, Development and Sustainability* 10(6): 745–67.

Obayelu, O.A., A.O. Adepoju, and T. Idowu. 2014. Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria. *Journal of Agriculture and Environment for International Development*108(1): 3–16.

Oduniyi, O.S. 2013. Climate change awareness: A case study of small scale maize farmers in Mpumalanga Province, South Africa. Master's thesis, University of South Africa.

Ogunniyi, L.T. 2011. Farmers' strategies for adapting to climate change in Ogbomoso agricultural zone of Oyo state. Agris On-line Papers in Economics and Informatics, 3(3): 3-13.

Okoye, C.U. 1998. Comparative analysis of factors in the adoption of traditional and recommended soil erosion control practices in Nigeria. Soil & Tillage Research 45: 251– 63.

Olaleye, O.L. 2010. Drought coping mechanisms: A case study of small scale farmers in Motheo district of the Free State province. Master's dissertation, University of South Africa.

O'Meagher, B. 2003. Economic aspects of drought and drought policy. In *Beyond drought: People, policy and perspectives*, ed. L.C. Botterill, and M. Fisher, 109–30. Clayton:CSIRO Publishing.

Paavola, J. 2008. Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. *Environmental Science & Policy* 11(7): 642–54.

Pannell, D.J., G.R., Marshall, N., Barr, A., Curtis, F. Vanclay and R. Wilkinson. 2006. Understanding and promoting adoption of conservation practices by rural landholders. Aust. J. Exp. Agric. 46:1407-1424.

Panley, S. 2009. *Drought, coping mechanisms and poverty: Insight from rainfed rice farming in Asia.* Beijing: International Fund for Agricultural Development.

Patil, S., T. Kelkar, and S. Bhalerao. 2013. Mulching: A soil and water conservation practice. *Research Journal of Agriculture and Forestry Sciences* 1(3): 26–9.

Pender, J., S Ssewanyana, E. Kato, and E. Nkonya.2004. Linkages between poverty and land management in rural Uganda. EPTD Discussion Paper No. 122. Environment and Production Technology Division, IFPRI (International Food Policy Research Institute, Washington, DC.

Pereira de Herrera, A.P., and G. Sain.1999. Adoption of maize conservation tillage in Azuero, Panama. Economics Working Paper No. 99-01. CIMMYT: International Maize and Wheat Improvement Center.

Pham Thi, T., and Y. Chaovanapoonphol. 2014. An evaluation of adaptation options to climate pressure on highland robusta coffee production, Daklak Province, Vietnam. *World Journal of Agricultural Research* 2(5): 205–15.

Polson, R.A., and D.S.C. Spencer. 1991. The technology adoption process in subsistence agriculture: The case of Cassava in southwestern Nigeria. *Agricultural Systems* 36(1): 65–78.

Polthanee, A., and A. Promkhambut. 2014. Farmers' perception of drought and its impact on a community livelihood in rural Northeastern Thailand. *Khon Kaen Agricultural Journal* 42(3): 427–42.

Reason, C.J.C., S. Hachigonta, and R.F. Phaladi. 2005. Interannual variability in rainy season characteristics over the Limpopo region of Southern Africa. International Journal Climatol 25: 1835–1853.

Reed,M.S., G., Podesta, I., Fazey, N., Geeson, R., Hessel, K., Hubacek, D., Letson, D., Nainggolan, C., Prell,M.G., Rickenbach,C., Ritsema,G., Schwilch,L.C. Stringer, and A.D. Thomas.2013.Combining analytical frameworks to assess livelihood vulnerability to climate change and analyse adaptation options. *Elsevier*. Ecol Econ. 94: 66–77.

Reimer, A.P., DK. Weinkauf, and L.S. Prokopy. 2012. The influence of perceptions of practice characteristics: An examination of agricultural best management practice adoption in two Indiana watersheds. *Journal of Rural Studies* 28(1): 118–28.

Rockström, J. 2003. Resilience building and water demand management for drought mitigation, Phys. Chem. Earth, 28: 869-877.

Roncoli, C., K. Ingram, and P. Kirshen. 2001. The costs and risks of coping with drought: Livelihood impacts and farmers' responses in Burkina Faso. *Climate Research* 19(2): 119–32.

Rouault, M., and Y. Richard. 2003. Intensity and spatial extension of drought in South Africa at different time scales. *Water SA* 29(4): 489–500.

Roy, A.K., and I. Hirway. 2007. *Multiple impacts of droughts and assessment of drought policy in major drought prone states in India*. Gujarat, India: Centre for Development Alternatives.

Russell, S.,and G. Hampton. 2006. Challengesin understanding public responses and providing effective public consultation on water reuse. *Desalination* 187: 215–27.

Sahu, N.C., and D. Mishra. 2013. Analysis of perception and adaptability strategies of the farmers to climate change in Odisha, India. *APCBEE Procedia*5: 123–27.

Sani, S., and T. Chalchisa. 2016. Farmers' perception, impact and adaptation strategies to climate change among smallholder farmers in Sub-Saharan Africa: A systematic review. *Journal of Resources Development and Management* 26: 1–8.

Sathaye, J.A., and J. Christensen. 1998. *Mitigation and adaptation cost assessment: Methods and approach use*. Roskilde, Denmark:UNEP Collaborating Centre on Energy and Environment, Riso National Laboratory.

Schipper, E.L.F. 2007.Climate change, adaptation and development: Exploring the linkages. Tyndall Centre Working Paper No. 107. Tyndall Centre for Climate Change Research, Norwich UK.

Scoones, I., V. Dzingirai, N. Anderson, E. MacLeod. L. Mangwanya, F. Matawa, A. Murwira, L. Nyakupinda, W. Shereni, and S.C. Welburn. 2017. People, patches, and parasites: The case of Trypanosomiasis in Zimbabwe. *Human Ecology*45(5): 643–54.

Semenza, J.C., D.E. Hall, D.J. Wilson, B.D. Bontempo, D.J. Sailor, andL.A. George. 2008. Public perception of climate change: Voluntary mitigation and barriers to behavior change. *American Journal of Preventive Medicine* 35(5):479–87.

Sen, A.K. 1981. Poverty and Famines: an Essay on Entitlement and Deprivation. Clarendon, Oxford. The Johns Hopkins University Press, Baltimore and London: 327-436.

Shah, K. U. and H. B. Dulal. 2015. Household capacity to adapt to climate change and implications for food security in Trinidad and Tobago. Regional Environmental Change, 15 (7): 1379–1391.

Shankland, A. 2000. Analysing policy for sustainable livelihoods. IDS Research Report No. 49. IDS, Sussex.

Shiferaw, B., and S. Holden. 1998. Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: A case study in Andit Tid, North Shewa.*Agricultural Economics* 18: 233–47.

Shisanya, C.A., and M. Khayesi. 2007. How is climate change perceived in relation to other socioeconomic and environmental threats in Nairobi, Kenya.*Climatic Change* 85(3): 271–84.

Shongwe, P., M.B. Masuku, and A.M. Manyatsi. 2014. Factors influencing the choice of climate change adaptation strategies by households: A case of Mpolonjeni Area Development Programme (ADP) in Swaziland. *Journal of Agricultural Studies* 2(1): 86.

Shoroma, L.B. 2014. Mitigating the effects of recurrent drought : The case of Setlagole community, Ratlou Municipality (North West Province).Master's mini-dissertation, North-West University.

Slegers, M.F.W. 2008. If only it would rain: Farmers' perceptions of rainfall and drought in semi-arid central Tanzania. *Journal of Arid Environments* 72(11): 2106–23.

Small, L.A. 2007. The sustainable rural livelihoods approach: A critical review. *Canadian Journal of Development Studies* 28: 27–38.

Smith, J.B., S.E. Ragland, and G.J. Pitts. 1996. 'A process for evaluating anticipatory adaptation measures for climate change. *Water, Air, and Soil Pollution* 92: 229–38.

Sofoluwe, N., A. Tijani, and O. Baruwa. 2011. Farmers' perception and adaptations to climate change in Osun State, Nigeria. *African Journal of Agricultural Research* 6(20), 4789–94.

South Africa. 2005. 'Drought Management plan: Department of Agriculture, Land Reform and Rural Development' *Government Gazette* vol 47 no 27186, dated 19 January 2005.

South African Weather Service.2015. Meteorological services under the South African government. http://www.weathersa.co.za/web/index.php (accessed October 28, 2016).

Statistics South Africa (Stats SA).2011.Available online:
http://www.statssa.gov.za/?page_id=993&id=mangaung-municipality (accessed February 13, 2018).

Swiderska, K., H.,Reid, Y.,Song, D.,Mutta, P.,Ongogu, P.,Mohamed, R. Oros, and S. Barriga. 2011. The role of traditional knowledge and crop varieties in adaptation to climate change and food security in SW China, Bolivian Andes and coastal Kenya. UNU-IAS, Mexico.

Tenge, A.J., J.de Graaff, and J.P. Hella. 2000. 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.

Thacher, T., D.R. Lee,and J.W. Schelhas.1997. Farmer participation in reforestation incentive programs in Costa Rica. *Agroforestry Systems* 35(3): 269–89.

Tideman, E., and V. Khatana. 2004. Drought coping strategies in semi-arid India.

IndoGerman Bilateral Project. “Watershed Management” German technical cooperation.

Tizale, C.Y. 2007. The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia. PhD thesis, University of Pretoria.

Traoré, N., R. Landry, and N. Amara.1998. On-farm adoption of conservation practices: The role of farm and farmer characteristics, perceptions, and health hazards. *Land Economics* 74: 114–27.

Tyson, P.D. and R.A.Preston-Whyte, 2000. The Weather and Climate of Southern Africa, Oxford University Press Southern Africa, Cape Town. pp Xii - 396.

Uddin, M.T., and H. Takeya. 2005. Resource interdependence and enterprise combination of integrated farming in some selected areas of Bangladesh. *Pakistan Journal of Biological Sciences* 8:405–12.

Uddin, M., W. Bokelmann, and J. Entsminger. 2014. Factors affecting farmers’ adaptation strategies to environmental degradation and climate change effects: A farm level study in Bangladesh.*Climate* 2(4): 223–41.

Udmale, P., Y. Ichikawa, S. Manandhar, H. Ishidaira, and A. Kiem. 2014. Farmers’ perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction*10(A): 250–69.

Ugwumba, C.O.A., R.N. Okoh, P.C. Ike, E.L.C. Nnabuife, and E.C. Orji. 2010. Integrated farming system and its effect on farm cash income in Awka south agricultural zone of Anambra State, Nigeria. American Eurasian *Journal of Agricultural & Environmental Sciences*8(1): 1–6.

United Nations, International Strategy for Disaster Reduction (UN/ISDR) (2009). Terminology on Disaster Risk Reduction. Available online: http://www.unisdr.org/we/inform/terminology (Accessed on 20 October 2017).

Van Zyl, J., C.McKenzie, and J. Kirsten.1996. Natural resource management issues in rural South Africa. In *Agricultural land reform in South Africa: Policies, markets and mechanisms*, ed.J. van Zyl, J.F. Kirsten, and H.P. Binswanger, 236−59. Pretoria: University of Pretoria.

Vedwan, N., and R.E. Rhoades. 2001. Climate change in the Western Himalayas of India: A study of local perception and response. *Climate Research* 19(2): 109–17.

Vogel, C.H. 1998. People and drought in South Africa: Reaction and mitigation. In*People and Environment in Africa*, ed. T. Binns, 249–56. Chicester: John Wiley and Sons.

Vogel, C. 2005. Seven fat years and seven lean years? Climate change and agriculture in Africa. *IDS Bulletin* 36: 30.

Vogel, C., and J. Smith. 2002. The politics of scarcity: Conceptualising the current food security crisis in Southern Africa. *South African Journal of Science* 98: 315–7.

Vogel, C.H., M. Laing, and K. Monnik. 2000. Drought in South Africa, with reference to the 1980-94 period. In *Drought: A global assessment*, ed. D.A. Wilhite, 348–67. London: Routledge.

Von Kotze, A. and Holloway, A. 1999. Living with drought: Drought mitigation for sustainable livelihoods'. Cape Town: David Philip Publishers.

Water Research Commission. 2015. Background to current drought situation in South Africa. WRC Drought Factsheet 1. Available online: http://www.droughtsa.org.za/drought-in-south-africa.html (Accessed 15 February 2018).

Weber, E.U. 2010. What shapes perceptions of climate change? *Climate Change* 1(3):332–42.

Wehbe, M.,H. Eakin, R. Seiler, M. Vinocour, C. Avila, and C. Marutto. 2006. Local perspectives on adaptation to climate change: Lessons from Mexico and Argentina. AIACC Working Paper No. 39. AIACC Project Office, Washington, DC.

Wilhite, D.A. 1993. Planning for drought In *Drought assessment, management and planning: Theory and case studies*, ed. D.A. Wilhite, 87−108. Boston: Kluwer Academic Publishers.

Wilhite, D.A. 2000. Drought preparedness and response in the context of sub-Saharan Africa. *Journal of Contingencies and Crisis Management* 8(2): 82–92.

Wilhite, D.A., and M.H. Glantz. 1985. Understanding the drought phenomenon: The role of definitions.*Water International* 10: 111-20.

Wilhite, D.A., and O, Vanyarkho. 2000. Drought: Pervasive impacts of a creeping phenomenon. In*Drought: A global assessment, natural hazards and disaster series*, ed. D.A. Wilhite, 245–55. London: Routledge Publishers.

Wilhelmi, O.V. 1999. Methodology for assessing vulnerability to drought: A Nebraska case study. Dissertation, University of Nebraska.

Yesuf, M., S. Di Falco, T. Deressa, C. Ringler, and G. Kohlin. 2008. The impact of climate change and adaptation on food production in low-income countries: Evidence from the Nile Basin, Ethiopia. December 2008. International Food Policy Research Institute.

Yirga, C.T. 2007.The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia. PhD thesis, University of Pretoria.

Yirga, C,T., B.I. Shapiro, andM.Demeke. 1996. Factors influencing adoption of new wheat technologies in Wolemera and Addis Alem areas of Ethiopia. Ethiopian Journal of Agricultural Economics 1(1), pp. 63–84.

ZENID. 2002. *Jordan's National Human Development Report 2: Sustainable Livelihoods*. United States. The Queen Zein Al -Sharaf Institute for Development.

Zhang, D., and W. Flick. 2001. Sticks, carrots, and reforestation investment. *Land Economics* 77(3): 443–56.

Zvomuya, F. 2007. Limpopo looks to the sky. NAFU farmer empowerment newsletter, June Issue, 25–27.