Assessing livestock farmers’ ecological knowledge and adaptation to climate
and environmental change in arid regions of South Africa

By

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DECLARATION

I declare that Assessing livestock farmers’ ecological knowledge and adaptation to climate and environmental change in arid regions of South Africa is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

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ABSTRACT

Challenges that come with micro-level climate change projections have resulted in the inadequacy of our understanding of local climatic changes and the appropriate adaptation strategies. This has resulted in indigenous communities relying on their local knowledge for local scale climatic changes and suitable adaptation practices. Coping and adapting to climate and its impacts has been occurring since human existence, however, humans are still vulnerable due to the rapid rate that the climate is changing. Adaptation is vital for all global people, especially living in semi-arid or arid regions, as it provides a solution for food shortages and livelihoods. Global livestock farmers have, over many years, accumulated local ecological knowledge; and it is from this knowledge that decisions are made. Local knowledge related to adaptation to climate change and variability has largely not been recognized or documented and it is only lately that it is deemed to be critical in formulating policies to mitigate the harsh effects of the rapidly changing climate. This study was focused on the local knowledge and understanding of climate change and variability (and associated environmental change) with its impacts and adaptation of communal livestock farmers in the semi-arid regions of the Northern Cape Province in South Africa. Two communal areas namely, Leliefontein and Steinkopf in Northern Cape served as study sites. A case study approach, with triangulation of focus group discussions and semi-structured interviews, was used. The focus group discussions were aimed at drawing up a seasonal calendar, where 10 livestock farmers from Leliefontein and 14 from Steinkopf participated. The focus group discussions were followed by in-depth semi-structured interviews, where a total of 20 livestock farmers from each study site were interviewed. While various other studies highlight the lack of awareness and understanding of climate change among livestock communal farmers, this study found that 90 % and 55 % of the interviewed Steinkopf and Leliefontein livestock farmers had an understanding of the phenomenon. The interviewed farmers referred to the phenomenon of climate change as “seasonal shifts” that they have been experiencing. Findings of the study indicated that intergeneration knowledge transfer and media sources contributed as sources of climate and farming management information. The basic, but wealthy knowledge
of farmers informs them of potential climate change impacts and possible adaptation strategies. The study also revealed that even though adaptation measures are being carried out by livestock farmers in the two study sites, that there are general barriers which include financial, biophysical environment, social and institutional barriers that inhibit effective adaptation. Recommendations from this study were that policies should consider and protect local knowledge; and that the factors that affect successful adaptation strategies of communal livestock farmers should be considered when adaptation programmes are planned.
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GLOSSARY OF TERMS

Adaptation
An adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts.

Adaptation capacity
The ability of a community to apply effective adaptation strategies to cope and adapt to extremes or moderate current or future climate change, variability and associated impacts.

Arid area
An area characterized by a limited or the lack of available water in a form of precipitation, thus preventing or decreasing the growth and development of plant and animal life.

Climate change
An overtime change in climate and its variables (temperature, precipitation and wind) due to human activities or natural variability; where this change continues for an extended period of time.

Climate projection
The result of an attempt to produce an estimate of a change in climate in the future, at seasonal, inter-annual or long-term time scales.

Climate variability
Deviations in the mean state of climate and irregularities of its variables, including year to year short-term fluctuations.
Drought  An extended dry weather for a duration ranging from seasons to year, which results from the lack of or reduced rainfall to levels below the average amount and often results in water shortages needed for human and agricultural use.

El Niño Southern Oscillation  The interaction between the atmospheric and oceanic temperatures in the tropical Pacific, resulting in warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru current. This interaction results in dry and wet climatic conditions in many other parts of the world.

Global Circulation Model  Three-dimensional mathematical models carried out on large horizontal resolutions to project changes in global climate.

Impacts  Effects on natural and human systems of extreme weather and climate events and of climate change.

Local Ecological Knowledge  Location specific knowledge that is based on observations and interactions with the environment that evolves by adaptive processes, and is passed on from generation to generation.

Resilience  The ability of a community to absorb and adapt to climatic and non-climatic stress and disturbances while retaining ways of functioning.
Transhumance
A strategy practiced by pastoral communities that involves the movement of livestock between grazing lands to exploit the seasonal availability of fodder and water.

Vulnerability
The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability takes into consideration the exposure, sensitivity, and adaptive capacity of the susceptible system.
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CHAPTER ONE: INTRODUCTION

1.1 Background

The International Panel on Climate Change (IPCC) (2007) identifies climate change as one of the major global environmental concerns that have resulted in local, national, regional and global attention due to its impact on food security, economies, human health and natural resources amongst others. Global changes projected for 2050 include 1.4 °C to 6.5 °C increases in temperatures, 18 cm to 59 cm rise in sea level and frequent extreme climate events such as heat waves, droughts, heavy rainfall and hurricanes (UNISDR, 2008). The year 2015 was the warmest year recorded globally, with a global temperature increase of above 1.0 °C (Climate Council, 2016; Hansen et al., 2016). According to the National Aeronautics and Space Administration (NASA), the first half (Jan-June) of year 2016 was even warmer. Most projections have been made for future temperature increase, however, there still remain challenges in the accuracy of future rainfall projections persist for regional scales (Patt, 2009). These challenges have resulted in various difficulties for communities whose livelihoods are dependent on rainfall.

While climate change is a global phenomenon, its effects are expected to be disproportionate between the wealthy developed countries and developing countries whose citizens largely live in poverty (Nkoana, 2014; Bele et al., 2014; Mandleni, 2011). Developing countries are known to be the most vulnerable countries to climate change, because of their dependency on agriculture, insufficient capital that inhibits their adaptation actions (Fischer et al., 2005), and slow technological advancements (IPCC, 2001). In South Africa for example, Juana et al. (2012a; b) have shown that impoverished South African households are the most vulnerable population group. Most people in developing countries practice subsistence farming with either livestock or crops (Madzwanumse, 2010); and production in these areas is believed to decline as consequences of climate change (Mandleni, 2011). This could have huge negative implications for the further impoverished in these countries.
1.2 Climate changes projections for the African continent

Climate change has been widely projected to have severe implications in Africa (Huntingford et al., 2005; Midgley et al., 2005). The IPCC has predicted the African continent to have temperature increases that are 1.5 times higher than that of the globe (Mandleni, 2011). This makes the people on the continent more likely to be vulnerable to climate change. Even though different models have been used, all indicate that African temperatures are expected to increase between 2 to 6°C by 2100 (Hulme et al., 2001), with a decadal increase of 0.2 to 0.5°C (Reid et al., 2007).

Precipitation has been projected to decrease over southern Africa (Reid et al., 2007); and this is due to the observed and projected weakening of the Southern African monsoon during 2000-2040 (Hulme et al., 2001). However, although these changes in climate may affect the whole continent, the spatial and temporal distributions of its impacts vary (Below et al., 2010). Scientists expect more frequent and longer dry periods in West Africa, which indicate a decrease in mean annual rainfall (Below et al., 2010). Climate change projections for countries along the Atlantic coast of Southern Africa forecast significant changes in the current climatic conditions by 2050 (Midgley et al., 2005; Bourne et al., 2012). These changes are increases in average annual temperatures and variability in rainfall where it is expected to increase in areas along the coast, but decrease as one goes further inland.

It is projected that rainfall patterns in South Africa are likely to change, leading to an increase in extreme events such as droughts and flooding which are often associated with the El Niño Southern Oscillation (ENSO) (Dilley and Hyman, 1995; Rojas et al., 2014), and an overall decrease in mean annual rainfall (Scholes and Biggs, 2004; Midgley et al., 2005; Bourne et al., 2012). Along the western parts of South Africa, mean annual temperatures are expected to rise between 2-3°C by 2050 (Bourne et al., 2012). The Karoo region in South Africa has been the recorded as most frequent to drought (Mandleni, 2011), thus affecting water availability to people and livestock in the surrounding area.
1.3 Constraints to livestock farming in arid rural areas

Livestock farming is regarded as one of the most ancient farming systems still being practiced globally. In Africa, most countries are dependent on agriculture as the major contributor to their economies, thus making agriculture the largest domestic producer in the continent (Hussein et al., 2008). Livestock farming plays a vital role in the sector for most countries (Ogunkoya, 2014). The most common animals include sheep, goats, cattle, equines, poultry and camels (Rust and Rust, 2013). Together these generate 92% of the total livestock agricultural income (Rust and Rust, 2013). There are additional reasons why farmers keep livestock that range from keeping livestock as part of their tradition, as a sense of wealth and investment strategy (Fafchamps et al. 1998), and to benefit from the by-products (Okungoya, 2014). These benefits are not often captured in national statistics and thus unrecorded. Furthermore, Musemwa et al. (2008) reveal that livestock farming also has a global potential to reduce food insecurity and poverty in communal areas.

Currently these farming systems are faced with various challenges (Ogalleh, 2012), which can be grouped into social, biological, economic, and political and management categories (Mupawenda, 2009). Livestock farmers in rural areas are faced with various challenges that restrain them from successful farming and generating sufficient income. For example, Thomas and Rangnekar (2004) reveal that some of these challenges include access to finance to purchase necessary inputs such as feed, veterinary services, and drugs; and the unavailability of relevant knowledge that is often provided by agricultural extension officers. Also, in developing countries, limited availability of resources especially land is regarded as one of the negative challenges (Steinfeld, 2004). Other examples include lack of access to water and functional markets, risks associated with livestock diseases (Montshwe, 2006), and livestock theft (Sikhweni and Hassan, 2013). The challenge of inaccessible functional markets was found by Musemwa et al. (2008) and Sikhweni and Hassan (2013) to be the main factor limiting South African communal farmers to generate a higher income. Another documented challenge in South Africa is livestock deaths due to wildlife predation. This was
documented in a study by Sikhweni and Hassan (2013), were communal farmers adjacent to the Kruger National Park reported that they live in constant fear of their livestock being eaten by wildlife. Wildlife predation is also evident in other African farming communities such as in Tanzania (Holmern et al. 2007) and Botswana (Kgathi et al., 2012). Climate change also constrains livestock farming but does not act independently as it interacts with other drivers that include ecological fragility, institutional weaknesses, poverty, and political instability which result in changes in agricultural systems (IPCC, 2007; Ogunkoya, 2014).

With climate change adding to the already prevailing challenges of farming in these areas livestock farming will be negatively affected (Gill and Smith, 2008). The negative impacts of climate change to livestock can be direct or indirect (Rust and Rust, 2013; Taqi et al., 2013). Direct effects include wind speed, air temperature, and humidity; which affect the animals’ milk and wool production, and the animals’ reproduction (Houghton, 2001). Indirect effects include ecosystem changes, forage resources (Rust and Rust, 2013), and frequency and distribution of diseases and pests (Thornton et al., 2007). Ecosystem and forage resource changes can lead to changes in the livestock’s diets and make it difficult for farmers to counter-act the forage deficits in the dry season (Thornton et al., 2007).

1.4 Livestock farming in South Africa

Livestock farming largely occurs in hostile environments (Nel and Hill, 2008) that are most vulnerable to climate variability and change (Thornton et al., 2007). Seventy percent of South Africa’s land is comprised of natural and semi-natural ecosystems (DEAT, 2004); where more than 90 % of these natural and semi-natural ecosystems is either arid or semi-arid (Hoffman et al., 2009). South Africa is the 30th most arid country in the world (SA Yearbook 2013/14); and according to UNICEF (2011), 70 % of the country’s population is located in these arid areas. Approximately 40 % of arid areas in South Africa are primarily occupied with extensive livestock farming (Nel and Hill 2008). South Africa’s average annual
rainfall of 495 mm (Benhin, 2006) is well below the global average of 860 mm (Hedden et al., 2013). South African rainfall regime varies across different regions where areas like Richtersveld bordering Namibia receive less than 50 mm and the mountains in the Western Cape receive above 3 000 mm per annum (Palmer and Ainslie, 2006).

Cattle, sheep, and goat production are the most important farming systems in South Africa; in both commercial and smallholder farming systems. About 52% of farming land in the country is for commercial livestock production, and 17% of the country’s farm land is occupied by the smallholder livestock production (Palmer and Ainslie, 2006). The combination of cattle, sheep and goat production contribute 20-30% of the country’s agricultural output per annum (Musewa et al, 2008). The smallholder sector alone accounts for 67% goat, 41% beef, and 12% sheep of the production (Ogunkoya, 2014). For various communities, livestock farming remains the primary source of income (Thornton et al., 2007).

Approximately 70% of South African farmers live in semi-arid and arid rangelands and rely on livestock farming as a means of livelihood as it seen as the only viable agricultural practice to withstand these climatically variable environments (Mapiye et al., 2009). Dryland ecosystems have supported livestock farming communities for centuries despite prevailing negative perceptions (UNEP, 2009). Dryland farming communities might be known to be resilient to change; however, the rate of climate change and variability has presented severe threats to farmers, especially in developing countries (Herero et al., 2010).

1.5 Climate change adaptation and the use of Local Ecological Knowledge

Even though environmental changes have become more erratic due to changes in climate variables (temperature, rainfall, and the wind), rural farmers have and are still continuing to use their Local Ecological Knowledge (LEK) to adapt to these climatic changes (Nyong et al., 2007; Egeru, 2012). Local Ecological Knowledge has been defined as ‘location specific knowledge that is based on observations and interactions with the environment that evolve by adaptive processes’
(Dudgeon and Berkes, 2003) and is transferred from generation to generation mainly through oral traditions (Luseno et al., 2003).

In the past, LEK has been neglected by the scientific community and considered non-vital (Allsopp et al., 2007; Egeru, 2012) but, due to the uncertainties of climate change this knowledge is now a valuable resource as it could provide insight on micro-level adaptation strategies (Ajani et al., 2013). Recently, LEK has been recognized as an important factor that needs to be incorporated in formal climate change adaptations (Speranza et al., 2010; Ajani et al., 2013). Thus, there is a need to record LEK and see whether climate change adaptations can be improved, so that vulnerable farming communities can become more resilient (Muller and Shackleton, 2013).

1.6 The research problem

It has been reported that accurate micro-level climate change projections are challenging to predict (UNICEF, 2011; Ziervogel et al., 2008), especially rainfall (Mertz et al., 2009). This limits our understanding of climatic changes with associated environmental changes and adaptation strategies appropriate at the local level (UNICEF. 2011). Most climate change projection models used are based on regional scales and are impractical to local farmers at micro-scales. Moreover, these regional projections are based mostly on crop-climate change models (De Salvo et al., 2013); thus many researchers (Schulze, 1993; Du Toit et al., 2001; Kiker, 2002; Kiker et al., 2002, Benhin, 2006) have focused their research in the crop sector of the agricultural industry. This does not mean that there are no researchers focusing on livestock farming, but climate change adaptation research on crop farming outweighs those on livestock. We thus see two concerns rising from all of this, firstly, livestock farmers have to rely on regional models for adaptation at local scales. Secondly, livestock farmers’ must make use of recommendations from crop models to inform livestock practices.

Most of the adaptation strategies practiced by livestock farmers are based on local ecological knowledge (Elia et al., 2014); and they regard them as effective.
adaptive strategies (Ajani et al., 2013). So farmers rely on their knowledge of their environment and climatic and environmental observed changes to derive solutions to cope. There have been discussions about what value local knowledge can bring to climate change adaptation strategies used by small-scale farmers (Mertz et al., 2009). However, these discussions are not based on how ecological knowledge is used to implement adaptation practices, but rather on how local knowledge and scientific knowledge compete with each other (Ajani et al., 2013).

Adaptation to climate change is not a future phenomenon to be undertaken when or if climate change occurs, but recognition that climate change is already happening and adaptation is a current activity that needs to be studied in both developed and developing countries (Grothmann and Patt, 2005). More studies need to be carried out in developing countries, especially in semi-arid or arid regions, because current trends of climate change show there is a high probability of these areas becoming deserts, thus affecting production. Also, there is a need for adaptation responses, and assessing local knowledge may be vital for knowing how local people understand climate change and the different actions they select to cope and adapt.

1.7 Significance of the study

The United Nations Framework Convention on Climate Change (UNFCCC) provides guidelines for climate change mitigation and adaptation. However, these guidelines are on a national scale, therefore excluding what is currently relevant to local communities. Recommendations from these reports tend to be limited to mostly financial and technology knowledge towards adaptation, and have failed until recently to adequately recognize traditional and indigenous people’s knowledge and coping and adaptive strategies.

This study will be able to inform the scientific community about the use of local knowledge in different adaptation strategies employed by livestock farmers in two different South African bioclimatic regions. It will also highlight the importance
of local ecological knowledge, and perhaps put emphasis on the use of this knowledge when adaptation policies are developed.

Since climate change is expected to alter the frequency and intensity of droughts on the west coast of South Africa, it is surely important to understand how communal livestock farmers in arid and semi-arid regions adapt to the observed climate and environmental changes. The local knowledge these farmers use is crucial to their survival and that of future farmers in these areas. With the global concern that local ecological knowledge is slowly degrading, understanding this knowledge and providing it to literature may be beneficial to extension officers and future livestock farmers in semi-arid regions. Availability of this knowledge in literature can serve as fundamental knowledge to future farmers that would be faced with extreme climate change events. The need to understand farmers’ understandings, observations, and adaptations to climate change could serve as a guide to future adaptation strategies (Deressa et al., 2011).

1.8 Research aims and research questions

The aims of this research are.

- To assess livestock farmers’ local knowledge on climate and associated environmental change
- To determine the types of changes in local climate and the associated environmental changes that farmers have experienced in their lifetime
- To determine the environmental indicators livestock farmers use to monitor climate
- To assess how livestock farmers have adapted to their changing landscape
- To determine the barriers that livestock farmers encounter to implement their adaptation strategies
This study will attempt to answer the following questions:

1. What is the understanding of climate change of livestock farmers in semi-arid regions of South Africa?
2. What changes in local climatic and environmental parameters have livestock farmers in semi-arid regions of South Africa experienced in their lifetime?
3. What are the local indicators used by livestock farmers in semi-arid regions of South Africa to monitor climate?
4. How have the observed local changes influenced the adaptation strategies employed by livestock farmers in semi-arid regions of South Africa?
5. How different are the observed local changes and adaptation strategies between two different semi-arid bioclimatic zones in South Africa?

1.9 Study Limitations and ethics statement

Although there are 10 villages in the Leliefontein Communal Area, only one village was chosen as the study site, but due to its location, being higher up in the mountains, it experiences different climatic conditions (highest rainfall, and thus referred to a semi-arid) to the other villages in the flatter, low altitude surroundings. This village receives more precipitation than other surrounding areas. For Steinkopf, the other study site, there was no specific village selected in the communal area, and data was collected within the town of Steinkopf where most farmers reside.

One of the challenges for this study related to the farmers’ perception and observations of climatic changes being stimulated with specific historical events such as the 2015 drought occurrence. Nevertheless, measures were taken to ensure that the study was not affected by the limitations. It was ensured in the study that more than one farmer per village in the Steinkopf area, was chosen in order not to generalize an individual’s perspective for the entire communal area. In cases of new information given by the respondent, other respondents were asked for the validation of that new information.
The use of case study research is commonly criticized by dependencing on a single case, and thus not reaching a generalized conclusion. Farmers in village commonages practice similar livestock management practices as the rest of the communal area (Samuels, 2013) and have similar socio-economic conditions. Caution should, however, be taken if the results of this case study research are to be extrapolated to other semi-arid regions in the Namaqualand region or the country. To confirm the validity of this study, I triangulated the methods.

The study was conducted in accordance with the generally accepted ethical guidelines for research on human subjects and cleared by the University of the Western Cape ethics committee. Principles of transparency, informed consent, confidentially and respect were maintained at all times.

1.10 Thesis structure

Chapter one: Introduction

The chapter gives the background to climate change and its impacts on livestock farming. This is followed by the research problem, research questions, and objectives. The limitations and scope of the study are also presented.

Chapter two: Literature review

Chapter two provides a comprehensive literature review focusing on climate change and variability in semi-arid and arid rangelands, with associated effects on livestock farming, farmers’ perceptions, and adaptation strategies. In this chapter, I explore different concepts inter-connected with climate change. I also explore the debate on the usefulness of General Circulation Models (GCMs) to local livestock farmers and their use of local knowledge to adaptation measures.
Chapter three: Study area and research methods

In this chapter I describe the geographical location, climate, vegetation and major land uses of Leliefontein village and Steinkopf Communal Area. This chapter also outlines why study sites were selected, the research methods used for data collection, and the reason for the choice of methods.

Chapter four: Livestock farmers understanding of climatic changes with associated impacts on rangelands

This chapter provides Leliefontein village and Steinkopf Communal Area livestock farmers’ understanding of climate change and variability, with perceived impacts to livestock farming. Major sources of climate change information are also reported. This chapter reports on what changes in local temperature, rainfall and wind farmers from both Leliefontein village and Steinkopf Communal Area have observed in their lifetime. I also compare farmers’ perceptions to recorded weather data from South African Weather Services. In addition to the farmers’ observations, I report on local indicators used by farmers to monitor climate and environmental change.

Chapter five: Livestock farmers adaptation strategies to perceived climatic and environmental changes

In this chapter, I record local adaptation strategies practiced by livestock farmers from Leliefontein village and Steinkopf Communal Area that are based on farmers perceptions. I also report on challenges that farmers in Namaqualand are facing that inhibit them to successfully adapt to climatic changes.
Chapter six: Conclusions and recommendations

This chapter presents the summary of the findings, overall conclusions and recommendations.
CHAPTER TWO: LITERATURE REVIEW

This literature review is based on climate change and variability in Africa and the expected coupled extreme weather events. It then further focuses on the uncertainties from the climate change model projections and the farmers perceptions of climate change. This approach continues to underline the impacts of climate change in the agricultural sector and highlights the need for adaptation. It also focuses on local ecological knowledge as a base for the farmers awareness, perceptions, and decision-making for adaptation.

2.1 Understanding the link between climate variability and climate change

According to the International Panel on Climate Change (IPCC), climate change is defined as “an overtime change in climate due to human activities or natural variability; where this change continues for an extended period of time, usually decades” (IPCC, 2007). This may be slow changes in temperature and variations in the frequency, extent, and severity of weather extremes (FAO, 2008; Patt, 2009). Tompkins and Adger (2004) further simplify this definition by stating that there are four ways in which climate change is displayed. These are (1) increases in seasonal and inter-annual variability, (2) gradual changes in mean climate conditions, (3) increases in the frequency of extreme events, and (4) rapid climatic changes that cause ecosystems to shift.

Climate variability is defined as “deviations in the mean state of climate and irregularities of its variables, including year to year short-term fluctuations” (Lambrou and Nelson, 2010; Ziervogel et al., 2006). Climate variability is thus considered to be related to climate change (Mudombi, 2015). The key point is that climate change can be due to climate variability (Mudombi, 2015) and changes in climate result in climate variability in terms of the timing, duration, intensity, frequency, and distribution of climate events (IPCC, 2012). Amongst other examples, extended droughts and floods are considered the main examples
of climate variability that pose major threats to impoverished communities. Such climate extremes are often associated with the El Niño Southern Oscillation (ENSO) (Dilley and Heyman, 1995; Rojas et al., 2014).

The IPCC (2007) identifies climate change and variability as environmental issues that have caused global, national and regional attention due to their impact on food security, economy, human health and natural resources. There is a general concern that climate change and increasing climate variability aggravate the already existing societal challenges (Mandleni, 2011). Climate variability has been detected by Ziervogel and Calder (2003) as most critical to rural societies because it affects the security of their livelihoods. Also, climate change and variability have both been identified by the World Conservation Union Report of 2004 (Paul, 2011) as a real phenomenon that impoverished societies should take necessary adaptation and amelioration steps against.

2.2 Climate change modelling and its uncertainties

Climate change modelling makes use of different scenarios to project future changes in climate and the associated impacts on the environment. The commonly used models are General Circulation Models (GCMs), which are three-dimensional mathematical models carried out on large horizontal resolutions to project changes in climate. The key components of GCMs are based on atmospheric, oceanic, ice cap and land surfaces processes (Samadi et al., 2010), which are then forced into Special Report on Emission Scenarios (SRES) to understand and predict how climate will change with changing greenhouse gas emissions (MacKellar et al., 2007).

The most challenging and limiting factor of climate change modelling is uncertainty in the prediction (Rust and Rust, 2013) and thus confidence in projecting these changes is generally low (Thornton, et al., 2014). Recently smaller-scale predictions have been used that make use of higher resolutions to create regional projections to reduce uncertainty. However, there are different types of downscaled models and they make use of different variables to generate
future projections. The other concern is that even though downscaling is possible, there still remains a concern that these projections only look about 30 years into the future; therefore, making it difficult for local farmers to make long-term adaptation decisions (Ziervogel et al., 2008). A further disadvantage of these models and their resolutions is that the scale used does not account for natural variability of a specific location; therefore, limiting micro-level predictions (MacKellar et al., 2007; Department of Rural Development and Land Reform, 2013). Even though there remain concerns about climate change models, projections from these models are vital for planning climate change adaptation recommendations. On a national scale, South Africa uses the process of embedding Regional Climate Models (RCMs) within a GCM and empirical downscaling to generate regional climate scenarios (UNICEF, 2011).

2.3 Extreme events and impacts on agriculture

The probability of extreme events such as droughts and floods occurring on the African continent are projected to increase with climate change, and this is mostly due to rainfall variation. Different areas are projected to experience different climate change impacts. For example, different models show that high latitudes are likely to experience increases in precipitation while the tropics and the subtropics are to experience decreases in precipitation (IPCC, 2007).

Floods, storms, and droughts are considered as the most damaging hazards of climate change and variability. These hazards do not only affect impoverished people living in remote areas but also affect urban areas. Damage to infrastructure caused by floods and storms are more relevant to urban areas and can result in economic losses. Drought is a hazard recognized to affect livestock production. Impoverished livestock and crop farmers are expected to suffer localized impacts of droughts (Morton, 2007; Miyan, 2014); due to various constraints such as decreased water availability. Results from a study conducted by Juana et al. (2012b) show that approximately 20 % reduction in water availability in South Africa will result in a 12 % reduction in agriculture.
2.3.1 Ecosystem changes

The climate is a major factor known to regulate plant species distributions and vegetation in variable environments. The IPCC (2007) states that any increase above 1.5-2.5°C in global temperature is known to likely result in changes in ecosystem structure, function and distribution. This, in turn, has negative influences on developing countries whose majority of people are dependent on natural resources (IPCC, 2007). With the projected increases in temperature of 2-3 °C by 2050 in the western parts of South Africa, ecosystems and their functions are expected to change. It is evident from the literature (Nkoana, 2014; Mandleni, 2011) that ecosystems, communities, and economies are and will continue to be impacted by climate change and variability.

Both of my study sites are situated in the Succulent Karoo biome in Namaqualand, Northern Cape Province, South Africa. Bioclimatic envelope models by Rutherford et al. (1999); Midgley and Thuiller (2007) indicate that the spatial extent of the Succulent Karoo biome might be reduced by 2050 due to climate change. According to these models, approximately 40 % of the biome would be replaced by a different vegetation type. Bourne et al., 2012 suggests that this biome in Namaqualand is projected to become more arid or expand its distribution under worst case scenarios. However, revised predictions Driver et al. (2012) reveal that the Succulent Karoo biome would not decrease, but actually, increase to occupy areas currently occupied by the Nama-Karoo biome in the future. The validity of outputs and the usefulness of these bioclimatic models have been questioned (Pearson and Dawson, 2003; Huntley et al., 2010; Araújo and Peterson, 2012), due to models assumptions. Bioclimatic envelope models assume (1) only climatic variables determine species distribution, (2) distribution of species will habitually be at equilibrium with climate, (3) the adaptive capacity of species for both the present and the future, is the same, and (4) interactions between species remains constant in future (Pearson and Dawson, 2003; Huntley et al., 2010; Araújo and Peterson, 2012).

Even though bioclimatic envelope models have limitations, both models (Rutherford et al. 1999; Midgley and Thuiller, 2007) show that vegetation
changes will occur and farmers will be confronting changing vegetation types. Whether the biome decreases or expands, its shift will increase the rate of desertification in the area due to rainfall reduction.

2.3.2 Forage quality and intake

It has been reported that livestock farming is likely to be the most negatively impacted sector due to climate change; where a reduction in rainfall would reduce fodder production (Madzwamuse, 2010). Increased temperatures are expected to change the quality of plant material (Thornton et al., 2007); and this change will decrease the animal digestion process (Hanson et al., 1993; Thornton et al., 2007). This can occur due to the effects that climate change and variability can have on the physical and chemical characteristics of plants, or by directly affecting feed intake and digestion in livestock. Physical effects can be caused by extreme climate events such as drought, which can lead to a decrease in forage quality due to plant tissue senescence (Dumont et al., 2015). Chemical effects that decrease digestion in ruminants include increases in cell lignification due to increased temperatures (Wilson et al., 1991).

Forage digestion can also be affected by heat stress (Lu, 1989). Reported impacts of heat stress decreasing digestion include a decreased food passage rate with increased food retention in the gastrointestinal tract (Silanikove, 1992), and a reduction in daily intake leading to a decrease in volatile fatty acid concentration (Schneider et al., 1988; Miaron and Christopherson, 1992). The decreased passage rate can be due to changes in reticular motility (Miaron and Christopherson, 1992). These changes can alter animal diets, and thus shift the feed management of smallholder farmers during the dry season (Thornton et al., 2007).

The study of Hanson et al. (1993) showed that average forage digestibility decreases under all climate change scenarios used in the study, mainly due to the increase in lignification of plant tissues (Minson, 1990). The models produced in the study (Hanson et al., 1993) also showed that during the summer months an increase in standing biomass with a decrease in nitrogen concentration in plants
can be expected. All of these changes result in a decrease in animal performance, where the rate of breaking down food is decreased. Semi-arid rangeland productivity is likely to decrease in the near future, consequently resulting in animal deaths especially during the dry season, and pastoralists having to journey longer migration routes in search of forage (Taqi et al., 2013).

2.3.3 Water availability and quality

Global water has been severely affected by climate change; especially in areas experiencing changes in rainfall patterns and increased the frequency of droughts (Müller, 2011). Water resources for pastoralists are expected to become scarce, especially in areas projected to have reduced rainfall (Amede et al., 2011). In the past, the East African lands were estimated to have a drought once in five years. This is now projected to increase to one drought in three years (Thornton and Herrero, 2009). Droughts are commonly grouped as meteorological, agricultural or hydrological categories, based on their characteristics (Sivakumar et al., 2010). A meteorological drought is characterised by periods of absence or reduction in precipitation relative to the average amount over certain duration (Sivakumar et al., 2010; Golian et al., 2015). An agricultural drought is characterised by the nature of meteorological drought which results in soil moisture deficit and impacts on agricultural activities (Łabędzki and Bąk, 2014; Zhou and Lui, 2016). A hydrological drought is characterised by a reduction or lack of precipitation, which results in less recharge to the surface and underground water bodies (Golian et al., 2015). Most droughts occur as a result of an extended meteorological drought (Sivakumar et al., 2010). For the purpose of this study, drought is defined as an extended dry weather spell for a duration ranging from a season to a year, which results from the lack of or reduced rainfall to levels below the average amount and often results in water shortages needed for human and agricultural use. Ericksen et al. (2012) projected that a total of 1.8 million cattle could be lost in Kenya due to the increase in the frequency of droughts. The southern part of Africa has been projected to have reached increased levels of water scarcity by 2025 (Madzwamuse, 2010), with South Africa expected to be
one of the countries to experience the highest scarcity (Benhin, 2006). With the possibilities of fracking in the semi-arid Karoo, water availability and quality will decrease further for the surrounding farming communities (De Wit, 2011; Okungoya, 2014).

Water quality is reported to decrease, thus raising more concern for livestock health (Okungoya, 2014). The quality of water is dependent on weather as an important factor impacting the water’s nutrient load and pattern (Zhu et al., 2005). With the projected warmer global climate, high temperatures will have an indirect impact on water bodies by increasing surface and groundwater nutrient load (Van Vliet and Zwolsman, 2008).

Besides the increasing temperatures, precipitation is also projected to increase in its intensity and this will result in increased erosion and runoff that will transport pollutants to water bodies (Delpha et al., 2009). This increase in pollutants being transported to water bodies is likely to occur after droughts or prolonged summers; where nitrogen will gradually be mobilized into soils during droughts and would later be flushed into water bodies in the beginning of a wet season (Wilby et al., 2006). Heavier rainfall will not only increase pollutants in water but will also increase the entry of pesticides in water (Probst et al., 2005).

2.3.4 Livestock diseases

As currently available natural resources and their quality are to decline due to climate change and variability, livestock farmers need to be aware of environmental changes and perhaps diseases, so they can adapt (Bele et al., 2014). Projected increases in temperature and variable rainfall patterns are known to likely spread existing livestock diseases (Mandleni, 2011); and in other cases result in the emergence of new diseases (Ahmed et al., 2013), such as foot and mouth disease (DEAT, 2004). A study by Thornton et al. (2002) showed that the increases in the outbreaks of bluetongue disease and the Rift Valley fever are due to changes in rainfall patterns. Variation in temperature and rainfall patterns may result in favorable environments for pests; and can thus result in rapid spread of
diseases (Baker and Viglizzo, 1998). Changes in day length control when and how ticks quest for hosts (Randolph, 2008).

As existing diseases become more frequent and new ones spread into new areas, impoverished farmers will likely be the ones most affected with livestock mortalities (Rust and Rust, 2013) as they would need to buy medicine (Mandleni, 2011). Leliefontein village and Steinkopf livestock farmers will be affected by the frequent of emerging diseases, as they live under poverty and cannot afford to buy western medication. A way in which these farmers can counter-act the already expensive medication is to rely on their traditional remedies for existing diseases. A challenge becomes evident with new diseases in new areas, as farmers do not have the necessary knowledge to treat these diseases, and thus have to rely on western medicines. Even though local remedies are at their disposal and some do use natural forage/veld plants, but with climate change and variability, these plants are also disappearing (Tangjitman et al., 2015).

2.4 Vulnerability of pastoral communities

Pastoralism involves the use of natural rangelands for livestock and is known to have evolved about 7000 years ago (Brooks, 2006). This farming practice has for centuries been the base of food security for most African populations (Brooks, 2006; Mandleni, 2011; Thornton et al., 2015). Based on archaeological evidence found in the Sahel, pastoralism in Africa developed as a direct coping response to long-term climate change and variability (Brooks, 2006). Approximately 45 % of the global land is occupied by livestock farming (Mandleni, 2011), and 43 % of land in Africa is arid and semi-arid land is used for livestock farming (UNEP, 2009). This has led to livestock farming being regarded as the most dominant land use (Mandleni, 2011; Nouman et al. 2014) and the fastest growing agricultural subsectors (Thornton, 2010), whose production is expected to double by 2020 (Nouman et al. 2014). Livestock farming in South Africa is the most important source of livelihood in communal rangelands. Keeping livestock in
these areas is a poverty reduction strategy and ensures food and income security for vulnerable communities.

According to the Fifth Report of the IPCC (2014), vulnerability is defined as “the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.” The vulnerability framework in the context of climate change research involves three main components which include sensitivity, exposure to climatic stress and adaptive capacity (Adger, 2006; Nelitz et al., 2013; Abid et al., 2016). Exposure is the degree to which a system experiences a climate-induced stress (Adger, 2006). The components of exposure include duration, frequency, and the extent to which the system is exposed to the hazard or stress (Burton et al., 1993; Kasperson et al. 2005; Adger, 2006). Sensitivity can be explained as the degree to which a system is directly or indirectly affected by the climate-induced stress (IPCC, 2001). Adaptive capacity is the ability of a system to cope or adapt to the climate-induced stress in order to decrease the exposure and sensitivity induced by the stress (IPCC, 2007; Engle, 2011). Local level perceptions, social circumstances, financial and information resources, and institutions are important for increasing adaptive capacity of local communities (Bryan et al., 2013; Gorst et al., 2015; Lebel et al., 2015).

The concepts of exposure, sensitivity, and adaptive capacity can be simplified by an example of a country experiencing a drought. It is often the impoverished people that are located in remote arid and semi-arid areas that are susceptible to droughts (exposure). The people living in the arid parts of the country are hit harder by the drought (sensitivity). Lastly, it is the people of that country with greater access and availability of resources who will find alternatives to access water during the drought (adaptive capacity).

Letsie (2015) recognizes two types of vulnerability, namely, social vulnerability and biophysical vulnerability. Social vulnerability considers social factors that influence the community’s susceptibility to harm and allows the capacity to respond to that hazard (Cutter et al., 2003). On the other hand, biophysical vulnerability is based on the understanding of the biophysical changes (including
socio-economic and non-climatic factors) in terms of the exposure to future change in climate and the sensitivity of the environment to that particular change (Nelitz et al., 2013).

Rural populations are expected to be most vulnerable to climate change and variability and the associated impacts because they experience the highest levels of poverty and are most dependent on natural resources (Below et al., 2010; Hisali et al., 2011; Department of Rural Development and Land Reform 2013). As a result, Africa has been categorized as one of the most vulnerable continents to climate change and variability because of its widespread poverty compounded by recurrent droughts, erratic rains and floods which limit the communities’ or individual’s capacity to effectively cope and adapt (Lema and Majule 2009). Various authors have argued that farmers will experience challenges in adaptation as current climatic and environmental changes globally are taking place at a rapid pace than what farmers have experienced (Muller and Shackleton, 2013). Droughts, floods and heat waves are projected to become more frequent in the current century, as a result of changes in mean climatic variables (IPCC, 2012). Rural populations, therefore, have a higher need to adapt to climate change and variability in order to continue their current land use practice. However, adaptation depends on how local communities perceive climate change and variability, how vulnerable they are and their adaptive capacity.

2.5 Case studies: farmers’ perceptions of climate change

People’s adaptation strategies, or lack thereof, depend on their perception and awareness of climate change (Juana et al. 2012a). Without an understanding, it becomes challenging to react to a natural phenomenon that results in various hazards. To reduce consequences of climate change on the farming sector, farmers need to have adaptation strategies (Juana et al., 2013). Various studies assessing climate change vulnerability, coping, and adaptation, and barriers to adaptation have been conducted in different countries. Nevertheless, each country
has different exposure to climate change risks (Juana et al., 2013); so location specific studies need to be carried out.

**India**

Varadan and Kumar (2014) conducted a study aimed at validating farmers’ perceptions of climate change in Tamil Nadu, India. They found that farmers have observed decreases in monthly rainfall; increases in temperature, with prolonged summers; increases in drought years and heat waves; and erratic rainfall patterns that have become unpredictable. Farmers in this area also mentioned that their observed changes in climate affect their agricultural systems. The change in rainfall patterns, either coming in late or early has resulted in crop failure in the area. Farmers also mentioned the occurrence of new pests and diseases in the area that resulted in declining crop yields and livestock mortalities. Due to the late monsoon, the cropping season has shifted by two months, as the first rains come two months after the normal time. The study concluded that the farmers’ perceptions were in accordance with scientific data for temperature and rainfall.

**Senegal**

Mertz et al. (2009) analyzed climate change perceptions and adaptations of farmers in Senegal. Their study showed that farmers in the Eastern Saloum area are highly aware of climate change; and perceived wind and variable rainfall patterns as the most critical factors of climate change. These two factors resulted in poor livestock condition and decrease in crop yields. However, when the farmers are asked to identify main challenges they are faced with, they did not mention climate change. The study concluded that even though farmers can be aware of climate change related issues; their responses are likely to be influenced by the mentioning of climate when questions are asked. It also concluded that responses from individual interviews may not validate responses of group discussions. The data presented in the study showed that climate is not the main
driver of change, but a combination of other socio-economic, cultural, and environmental drivers. The authors thus highlighted that their study was limited in scope and thus firm conclusions on the adaptive capacity of the communities they studied cannot be made.

**Zambia**

A study carried by Nyanga *et al.* (2011) with 469 farmers from 12 districts in Zambia reported that majority of farmers perceive an increase in the duration of the cold season while the hot season has remained the same, and rainfall duration has reduced. Drought and flood frequencies were also noted to have increased over the years. Common adaptation measures taken by the farmers in the different districts include crop diversification, gardening, and conservation agriculture, increasing livestock diversity, and seeking support from veterinary officers. The study highlighted that farmers’ perceptions need to be considered in the design and implementation of adaptation projects.

**South of Africa**

Hassan and Nhemachena (2008) surveyed farmers’ adaptation strategies in South Africa, Zambia and Zimbabwe. The study was aimed at describing farmers’ perceptions of long-term temperature and precipitation changes, as well as farm level adaptation and barriers to adaptation. Farmers perceive temperature increase, aridity increase, changes rainfall patterns and drought frequency. Barriers to adaptation included lack of credit facilities, information on adaptation strategies, and inadequate farming inputs. The study highlighted that gender, farming experience, access to extension services, access to credit facilities and markets are the major factors of adaptations to climate change.

A study by Thomas *et al* (2007) was aimed at describing a 50-year period of rainfall variability and how farmers in South Africa respond to this variation. They found that farmers’ main concerns to climate change are the unpredictability
and changes in seasonal patterns. Farmers observations included short wet seasons with little but intense rainfall starting later; and the summers with intensified temperatures than the previous years.

Another South African study (Gandure et al., 2013) where 13 focus group discussions were conducted centered on perceptions of climate change variables, adaptations to climatic changes, and factors inhibiting adaptation. Results from this study show that temperatures increase during the summer season, but decrease during the winter season. Precipitation results showed that rainfall duration has decreased in the area that was studied.

From the case studies, we can see that farmers within the same community may perceive climate change differently. For most research done with local farmers on the African continent, it is evident that one of the major impacts they are experiencing is the delay in rains and increase in summer months that often result in low agricultural production.

2.6 Climate Change Adaptation

The weather is erratic, increasing in its variability and unreliable to livestock farmers. This calls for livestock farmers to be aware of the effects of weather patterns in the immediate and long terms. It also calls for adaptation measures that can be taken to curb the negative effects of climate change and variability on livestock production (Paul, 2011).

Coping and adapting to climate and its impacts has been something that has been occurring since human existence, however, humans are still vulnerable (McDowell and Hess, 2012). Adaptation is vital for people living in semi-arid or arid regions, as it provides a solution for food shortages and livelihoods (Katanha and Chigunwe, 2014). Studies that have been focussing on climate change adaptation noted that adaptation differs in different places and time (Katanha and Chigunwe, 2014). Examples include rural communities in Sahel that have coped with erratic climate to ensure their survival (Mertz et al., 2009). However, the
new challenge is the rapid rate at which climate variables are changing, thus affecting people who are dependent on natural resources. This challenge of the rate of climate then results in other challenges that push the people dependent on natural resources to their thresholds, therefore testing their adaptability (Marshall and Stokes, 2014). One of the ways in which affected people can respond to climate change is through adaptation.

The definition of adaptation is diverse depending who is adapting and to what (Ahmed and Long, 2010). In the context of climate change, adaptation is defined according to the International Panel on Climate Changes (IPCC) (2001) definition:

“Adaptation is an adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts”.

It is from this definition that the aim of adaptation can be formed, that is the use of strategies to reduce socio-economic vulnerabilities brought by climate change and variability. The United Nations Framework Convention on Climate Change (UNFCCC) in 1992 stated that adaptation and mitigation were responses people need to take to deal with climate change and variability. For most years after 1992, mitigation strategies were the main concern; and adaptation strategies were overlooked. It was only when the predicted climate change scenarios were extreme, and non-corporation to mitigation policies occurred, that adaptation was considered (Ahmed and Long, 2010).

Traditional and newly introduced adaptation strategies help African farmers to cope with current climate variability. There have been discussions about the adaptation strategies of small-scale farmers to climate change, but these debates are not based on the knowledge livestock farmers have about existing and potential adaptation practices (Below et al., 2010). This is part of the reasons why Hisali et al. (2011) state that the need to identify and understand potential adaptation strategies is crucial for decision makers.
Climate change and variability will not independently affect the livelihoods of farmers in developing countries (Mandleni, 2011), but there are other factors that are already burdens to these people. Examples of these factors include poverty, land use changes, land degradation (IPCC, 2007), local and national government structures, land tenure systems, and finances (Grothmann and Patt, 2005) to name a few. The latter are institutions that affect the availability and security of natural resources to people (Mandleni, 2011). The addition of these factors to climate change and variability, inform adaptation to be seen as a continuous stream of research, decisions, activities, actions and attitudes that are combined to inform decisions about all aspects of life (Nelson et al., 2007; Tompkins et al., 2010).

Sustainable adaptation in developing countries is vital, as these countries are dependent on natural resources (Department of Rural Development and Land Reform 2013). It requires a knowledge base, which may enable people to anticipate change to further obtain the required resources (Vincent, 2007). However, the appropriateness of these knowledge base needs to be properly understood (Ajani et al., 2013).

There are various examples of adaptation strategies practiced by African farmers, in both cropping and livestock farming sectors. Farmers in Mali coped with short rainy seasons by planting varieties of sorghum that have short life cycles (Lacy et al., 2006). A study by Thomas et al. (2007) found that farmers in the Limpopo, KwaZulu-Natal and North West Provinces of South Africa shifted their farming practices in the year 2003 from cropping to livestock, due to frequent droughts and rainfall variability. In terms of livestock farming, selling of livestock is one of the ways farmers in Burkina Faso adapted to droughts (Roncoli et al., 2001); and mobility is an adaptation strategy practiced by livestock farmers in Kgalagadi South, Botswana (Kgosikoma and Batisani, 2014). Other adaptations by African livestock farmers include migration routes out of rainfall declined areas (Ajani et al., 2013), changes in migration times and other activities such as the purchase of fodder during droughts (Muller and Shackleton, 2013).
2.7 Local Ecological Knowledge (LEK) in climate change adaptation

For most underprivileged countries in the world, the majority of their knowledge on agricultural management decisions stem from LEK; from which adaptation strategies are formulated, changed and transferred (Adger et al., 2005; Nelson et al., 2007). There are various definitions of Local Ecological Knowledge, due to the large body of literature on it. For the purpose of this study Local Ecological Knowledge is defined as:

"a cumulative body of knowledge, practice, and belief evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 1999: 8).

The term ‘practice’ highlights the adaptation strategies of livestock farmers; ‘belief’ highlights the livestock farmers’ perceptions of climate change and variability, and ‘adaptive processes’ emphasizes how livestock farmers have gained knowledge through years of experience. Due to local or global environmental changes as well as the exchange of ideas or knowledge between people, LEK is not stagnant but continuously evolves (Davis and Wagner, 2003).

Livestock farmers have over many years accumulated local ecological knowledge, and it is from this knowledge that decisions are made (Berkes et al., 2003). This accumulated knowledge enables farmers to know which plants are suitable and in good quality for livestock forage during different seasons, (Fernández-Giménez, 2000) but taking into consideration the distance from water point during the dry season (Samuels, 2013).

Local Ecological Knowledge can, therefore, be seen as the closeness of the local people with their environment due to their dependence on natural resources. One can, therefore, say that LEK is embedded in the people’s experiences, observations (Ghorbani et al., 2013; Fernández-Giménez and Estaque, 2012), and people’s needs (Davis and Wagner, 2003). Besides the cultural beliefs, other
attributes such as occurrence, distribution (ecology) of the particular resource they require, social institutional systems that describe essential aspects of human-environmental resource relations are considered in LEK systems (Davis and Wagner, 2003). For example, over generations farmers have been using LEK to determine the potential production of their area for their animals to feed on. Amongst many indicators they look at, farmers use elevation, soil-water dynamics, soil properties, topography and availability of annual and perennial plants (Newsham & Thomas, 2009). So based on these potential indicators, local people have accumulated this local knowledge based on environmental change over long periods and have thus used this knowledge to recognize and develop adaptation strategies (Wiid and Ziervogel, 2012). For example, local people of Sahel have established and implemented adaptation strategies that reduce their vulnerability to climate change, based on their indigenous knowledge systems (Egeru, 2011).

Livestock farmers in the Namaqualand region of South Africa for example, have developed in-depth ecological knowledge which allowed them to adapt to climate and environmental change (SPP, 2003; Samuels, 2006). Local Ecological Knowledge is not only used in climate change adaptation in Namaqualand but also in ethnobotany and restoration practices. Botha et al., (2008) assessed how crop farmers use LEK in Namaqualand for the restoration of the pre-mined lowlands and discovered that these farmers are aware of their environment and are practicing restoration practices (e.g. wind nests) based on their experiences. This proves that LEK is significant to people dependent on natural resources.

Thomas et al., 2007 noted that perhaps it is the time that the research community acknowledges its limits in studying climate change, and try and integrate the scientific knowledge with the knowledge of people who experience and are affected by climatic changes in their everyday lives. Some adaptation measures might not make sense if there is no understanding of (1) why certain measures are taken, and (2) when are they taken at that time. This is where local knowledge becomes vital in the understanding of the community’s adaptive capacity (Ogalleh et al., 2012). With the dependency on natural vegetation, insufficient capital and
slow adoption of using technology, farmers in developing countries had to rely on their local ecological knowledge to adapt to climate change.

Even though local farmers have this in-depth knowledge it is however limited to only focusing on experiences and observation that directly affect their survival (Ruddles and Davis, 2011). Using this knowledge in scientific research, therefore, requires caution as farmers use this knowledge for their own interest and needs. Even so, this knowledge needs to be reordered for future generations, since in many communities this knowledge is not actively being used, modified or even passed down to younger generations due to socio-economic and cultural changes (Fernández-Giménez and Estaque, 2012). Simelane (2005) explains it by saying that the loss of this knowledge is due to modernization that disconnects people from their traditions.

2.8 Barriers to adaptation

Climate change and variability does not affect the environment alone but, also affects the social, economic and political spheres (Mudombi, 2015). It is in this view that adaptation to climate change may be constrained by the social, economic, institutional and political environment in which people must operate (Fahim et al., 2013). Strong cultural beliefs, practices, and values may inhibit adaptation (Adger et al., 2012; Antwi-Agyei et al., 2013). Institutional factors mostly affect agricultural technologies; and amongst others, they include access to information via extension services (Maddison, 2006) and credit accessibility (Deressa et al., 2009).

It is assumed that farmers with access to extension information are aware of changes in climate change and possible adaptation measures (Gbetibuou, 2009; Deressa et al., 2009). Information from extension services is a vital factor amongst Sub-Saharan Africa farmers which promotes increased intensity for adaptation (Mandleni and Anim 2011; Gbetibuou, 2009; Antwi-Agyei et al., 2013). The lack of climate change information and awareness can serve as barriers to climate change adaptation (Adger et al., 2009; Antwi-Agyei et al.,
In most cases, this information of expected climatic changes, impacts, and potential and innovative ways to adapt is supposed to be provided by extension officers. However, in most Southern African countries, the extension officers are overwhelmed with numerous tasks and communities that make it practically impossible for them to attend to all needs of local farmers (Antwi-Agyei et al., 2013).

Adaptation policies are centrally driven by governmental structures that focus on a national level and sometimes constrain adaptation strategies at a local level (Antwi-Agyei et al., 2013). Local decision makers wanting to adapt have little power to institutions and policies that govern management and use of resources (Antwi-Agyei et al., 2013). For example, with the expected increase of water scarcity, decisions about the necessary water allocation within a country are made by governmental stakeholders (Barnett et al., 2015). The lack of community infrastructure maintenance, poor physical infrastructure, and the scarce meteorological equipment to produce local-scale climate information are also barriers to climate change adaptation (Antwi-Agyei et al., 2013).

Adaptation requires direct or indirect costs, thus hindering adaptation strategies of impoverished people with limited finances. Access to affordable credit is another financial factor inhibiting farmers from adapting successfully. The lack of credit facilities was reported to be one of the major barriers to implementing appropriate change adaptation strategies amongst Ethiopian farmers (Bryan et al. 2009). Farmers living under the poverty line struggle to meet the transactional costs in cases where they require credit for adaptation measures (Acquah de Graft and Onumah, 2011; Nhachena and Hassan, 2008). Though related to institutional barriers; the lack of markets hinders adaptation of most African communities (Antwi-Agyei et al., 2013). It is from these markets that farmers sell their products in exchange for money or as an adaptation strategy to livestock farmers (Deressa et al. 2009; Silvestri et al., 2012; Bishaw et al., 2013).
CHAPTER THREE: STUDY AREA AND RESEARCH METHODS

3.1 Leliefontein Communal Area

3.1.1 Geographical location

The Leliefontein Communal Area is located in the Namaqualand region and is under the administration of the Kamiesberg Local Municipality in Northern Cape, South Africa. The total size of the communal area is about 192 000 hectares and spans across an east-west direction of the Kamiesberg Mountains. The communal area is made up of 10 villages (figure 3.1), where the Leliefontein village is the oldest and highest lying village at 1 350 masl (Anderson, 2008; Samuels, 2013).

![Figure 3.1: Location of the Leliefontein Communal Area with its 10 villages in Northern Cape, South Africa (adapted from Samuels, 2013).](http://etd.uwc.ac.za/)

3.1.2 Climate

The western parts of Namaqualand receive most of its rain during the winter months from May to September, and the eastern parts receive most of its rain...
during the summer months from October to February. However, rainfall is generally variable and unreliable in terms of its amount, duration and distribution within these two rainfall regimes.

Rainfall in the communal area is divided into summer and winter rainfall areas. The eastern side of the communal area near Kamassies village receives summer rainfall and the rest of the communal area receives winter rainfall (Kotze et al., 2010). Mean annual precipitation for Leliefontein village in the uplands over the past 102 years was 392 mm (CV=0.44) and 145 mm for Garies (a town adjacent to Kheis village in the lowlands) (CV=0.35) (South African Weather Service Unpublished data). Winter months are April to September where most rains for the past 100 years fell from June to August as shown in figure 3.2. Winter rainfall is a result of cold, westerly fronts that bring gentle showers and the mountain landscapes that result in orographic rainfall to areas located in the mountains. Frost is common in winter in areas above 1000 m, and snow falls on average once or twice a year, mainly in areas above 1200 m (Helme and Desmet, 2006).

Figure 3.2: A 100-year summary in average monthly rainfall for Leliefontein Communal Area for years 1915 to 2015 (South African Weather Services Unpublished data).
Summer temperatures may exceed 40 °C and winter temperatures can be below freezing in the mountainous areas and often result in snow (Samuels, 2013). Actual temperature data available for the area shows that the average minimum temperature during winter from 2002 to 2012 ranges between 5 – 11.5 °C. Tropical thunderstorms sometimes reach the eastern parts of the mountainous region in late summer (February-April) and arrive as highly variable violent downpours (Desmet, 2007).

3.1.3 Vegetation

Vegetation in the Leliefontein Communal area is mainly shrubland. Two different biomes are found in this area namely; Succulent Karoo and Fynbos (Hilton-Taylor, 1994; Cowling et al., 1999). The lowlands are dominated by Succulent Karoo biome which is known to be the only global biodiversity hotspot to be entirely arid (Myers et al. 2000; Anderson, 2008; Samuels, 2013); and about 4750 plant species are contained in this biome (Cowling and Pierce, 1999), of which 25 % are endemic (Desmet, 2007). Endemic families with the most species richness include Asteraceae, Fabaceae, Poaceae, Crassulaceae and Aizoaceae (Desmet, 2007).

According to Driver et al (2003), the biodiversity found in this biome is under threat from mining, crop farming, overgrazing by livestock and climate change. These authors further state that approximately 3.5 % of this biome is formally conserved and the rest exposed to the above-mentioned pressures. The small percent of the biome being formally conserved has led to 5 % of it been permanently transformed (CSA, 2013). Of this 5 %, about 3 % is a result of mining and the remaining 2 % is due to crop farming; making mining the biggest land transformation within the biome.

The uplands and mountainous areas of the communal area are dominated by the Fynbos Biome (Debeaudion, 2001), which is also a global biodiversity hotspot. Plant families found in this biome include Asteraceae, Fabaceae, Ericaceae and Proteaceae, which are found on the highest mountain peaks (Hilton-Taylor, 1994).
The Leliefontein village is located in this biome but when farmers move down the mountain during winter, they move into the Succulent Karoo. The diversity seen in the communal area is distributed across nine vegetation types, that include the most transformed and threatened vegetation in South Africa, namely Renosterveld (Kemper et al., 2000). *Elytropappus rhinocerotis* (renosterbos) which is unpalatable to livestock is the most dominant shrub found this area. Geophytes are also found in abundance during winter.

Vegetation in the area has however been transformed by overgrazing, and this has been assumed as one of the main causes of vegetation transformation and degradation in communal areas (Hoffman et al., 2003; Hoffman and Rohde, 2007; Hoffman, 2014). Studies (Todd and Hoffman, 1999, 2009; Anderson and Hoffman, 2007) conducted in the Kamiesberg have shown a decline in the plant cover of succulents and palatable perennial shrubs as a result to overgrazing in the lowlands, and in areas close to water points and villages. If these changes brought upon by overgrazing continue for decades and are irreversible, they can lead to higher rangeland degradation (Anderson and Hoffman, 2007).

### 3.1.4 Land Uses

Two farming practices; namely crop and livestock farming are mainly practiced in the area. Livestock farming is more dominant than crop farming due to limited and unpredictable rainfall in the area. Also, livestock farming is tradition that the people of the communal area have kept from their forefathers (Swarts, 2015)

**Crop farming:** Since crop farming production is highly dependent on rainfall, this type of farming constitutes a small part of the livelihoods in the area (Debeaudion, 2001). However, in areas where conditions are suitable, cultivation of arable land allotments takes place (Swarts, 2015). There are currently 559 demarcated cropping units and food gardens in Leliefontein Communal Area with a combined size of 23 050 ha, which is 12 % of the commonage’s area. About 66 croplands were being used annually from 1996 to 2009 (Samuels, 2013). Traditionally, these croplands were open, but farmers have started fencing off their lands for private
use. Presently, all crops grown are for the purpose of supplementary feed to livestock during dry periods.

**Livestock farming:** Herded small stock of mainly sheep and goats are the dominant livestock kept in the Leliefontein. Free ranging large stock, mainly cattle and donkeys are also found in the area, but they constitute a small portion of the livestock (Debeaudion, 2001). Small stocks are managed by experienced herders whose knowledge originates as a response to environmental and social drivers (Samuels, 2006).

**Herding strategies:** Optimal use of limited resources is made possible by different herding strategies (Fernández-Giménez and Swift, 2003). These strategies are categorized by the movement of livestock herds. Baker and Hoffman (2006) investigated these strategies in the Leliefontein Communal Area, and they identified three different types. These included (i) sedentary herders, (ii) home-range herders, and (iii) mobile herders. Sedentary herders were described as herders that do not practice transhumance, while home-range herders were described as the ones that regularly practice transhumance when environmental circumstances become highly unbearable, and mobile herders were described as the ones that constantly practice transhumance annually.

Debeaudoin (2001) further classified herding strategies during a normal rainfall year based on daily grazing management. She recognized herders that herd livestock the whole day and decide the grazing route so they can take the animals to water points. There are also herders that leave livestock on their own the whole day and only look out for predators, and other herders follow livestock for the whole day but do not decide the grazing route (Debeaudoin, 2001). Samuels (2006) conducted a study in one village (Paulshoek) within the Leliefontein Communal Area, to further analyze if these herding strategies change during a drought. He found that some farmers find innovative strategies, and these were classified as selective and nomadic herding strategies. Selective herders split their
herds between the weak and strong animals and only herd the weak ones. This splitting is a resource partitioning strategy to ensure that the differently abled animals can access necessary resources (Fernández-Giménez and Swift, 2003). Nomadic herders migrate for a few days to underutilized areas to access better food quality.

People keep livestock for different roles (Fafchamps et al. 1998; Okungoya, 2014); and this is similar in Leliefontein. In addition to traditional practices, a range of other reasons for livestock keeping are prevalent in the communal areas. These include (1) economic benefit for poverty reduction (Samuels, 2006), (2) investment for children’s education, (3) meat consumption, (4) gifts to friends or family, and (5) wedding gifts (Modisele, 2001).

### 3.2 Steinkopf Communal Area

#### 3.2.1 Geographical location

Steinkopf is situated in the northern parts of Namaqualand in the Northern Cape (figure 3.3), under the administration of the Nama-Khoi Local Municipality. Both Steinkopf and Leliefontein fall under the jurisdiction of the Namakwa District Municipality. Steinkopf is the largest communal area in Namaqualand stretching from the Ikosis Mountains around Springbok north to the Orange River. The entire Steinkopf Communal Area is about 329,000 hectares, which excludes the land acquired through land reform, of which some of its residents have access to.
Figure 3.3: Location of the Steinkopf Communal Area in Northern Cape, South Africa with its associated bioregions.

3.2.2 Climate

There is no long-term rainfall data available for the Steinkopf area. The administrative town of Springbok’s data, which is about 40 km from Steinkopf, is mostly used to describe rainfall patterns in Steinkopf. Steinkopf is largely semi-arid with relatively low rainfall but the northernmost parts adjacent to the Orange River are arid (CSA, 2012). The entire commonage is split into winter and summer rainfall regions. On the west side of the N7 national road is mainly winter rainfall (approximately two-thirds of the land) and to the east mainly summer rainfall (Emmett, 1987). The Bushmanland region in the east receives summer rainfall (December-February) with 27 mm reported in year 2007, while the mountainous regions in the west receive winter rainfall (June-August) (Figure 3.4) (Oakley, 1999) which was totalled at 198 mm for the same year (South African Weather Services Unpublished data). Drought is a common feature in the area that usually results in high livestock mortalities. However, there are events where rainfall might be sufficient for non-perennial rivers to flow (Oakley, 1999).
Figure 3.4: A trend in total monthly rainfall for Steinkopf Communal Area for years 1915-2015. Springbok data is used as a proxy (South African Weather Services Unpublished data).

Temperature data shows that the summers are hot and winters cold, with the relatively large difference between seasons. Maximum temperatures mostly occur during February and can reach 30 °C, while minimum temperatures mostly occur in July and can reach 6.7 °C (South African Weather Service Unpublished data). Frost may occur in the higher-lying areas.

3.2.3 Vegetation

Steinkopf extends over the Succulent Karoo, Nama-Karoo and Desert biomes (Mucina and Rutherford 2006). The area also includes the endangered Lower Gariep Alluvial Vegetation on the banks of the Orange River. Five vegetation types occur in Steinkopf namely: Kosiesberg Succulent Shrubland, Southern Richtersveld Scorpionstailveld, Umdaus Mountains Succulent Shrubland, Anenous Plateau Shrubland and Namaqualand Shale Shrubland vegetation types (CSA, 2012).
The Nama-Karoo is located on the central plateau of Northern Cape, extending into the Southeastern parts of Namibia (Mucina et al. 2006; Khavhagali, 2010). Elements of the Succulent Karoo and Fynbos biomes are evident towards the south and west parts of the Nama-Karoo, by the presence of Aizoaceae and Asteraceae plant families. Other plant families found in this biome include Crassulaceae, Poaceae, Apocynaceae, Capparaceae, and Euphorbiaceae, to name a few. As compared to the other South African biomes, the Nama-Karoo contains low levels of endemism which are mostly concentrated in the Upper Karoo Hardeveld (Mucina et al., 2006). Even though this biome has low levels of floristic diversity, there is however high diversity of plant life forms. Examples of these life forms include dwarf shrubs, grasses, geophytes, annuals, and succulents.

The Desert Biome in South Africa is located in a small area in the lower Orange River valley (Rutherford, 1997). This biome experiences harsh environmental conditions, as compared to the Succulent Karoo and Nama-Karoo biome (Khavhagali 2010). Even though experiencing harsh environmental conditions, this biome still provides grazing to livestock in surrounding pastoral communities (Desmet et al., 2006). Dominant vegetation found in this biome is annual plants, which mainly annual grasses (mostly *Stipagrostis sabulicola*) (Khavhagali 2010), however, some areas have shrubs (mostly *Welwitschia mirabilis*) (Rutherford, 1997). Perennial plants are mostly also found in specialized areas with the presence of water in this biome. Mean annual rainfall for this biome ranges between 10 mm in the east to 70-80 mm in the west (Rutherford, 1997). During normal years, the plains appear bare, but covered with short annual grasses after abundant rains (Khavhagali, 2010).

Due to the dependency on livestock farming for the people in Steinkopf, overstocking has progressively had an impact on vegetation and has been identified as a major threat to the biodiversity in the Succulent Karoo biome and the Nama-Karoo biome (Mucina and Rutherford 2006; Mucina et al., 2006), as was mentioned by Driver et al (2003). According to a veld assessment conducted by Conservation South Africa (2012) in Steinkopf, excessive grazing and the
clearing of certain areas of natural vegetation for cropping has resulted in the dominance of *Galenia africana* in many parts of the rangeland.

### 3.2.4 Land Uses

Most households in the area have Nama origins. Prominent land uses in the area are livestock farming of mostly small stock and cultivation of arable fragments when conditions are suitable for growing additional feed for livestock. However, there are date palm tree plantations along the Orange River, near the Henkries village. There are also farmers who keep cattle. There are approximately 50,000 livestock that grazes in the area (CSA, 2012). During winter and spring months, the livestock are held in the winter rainfall region on the west side of the N7 and during summer and autumn livestock is moved to the summer rainfall region (Bushmanland or Orange River) east of the N7 national road (Carstens, 1961). There is also a small portion of farmers who also own horses and donkeys and utilize them for draught power.

Donkeys were historically used for draught power for ploughing and served as ‘machinery’ that separated grains from straw after harvesting. The introduction of motorized transportation and the introduction of machinery lead to the abandonment of horses and donkeys and they are currently used to a lesser extent only for transportation. This abandonment of these previously domesticated animals resulted in them becoming feral and believed to cause vegetation transformation in the area.

### 3.3 METHODS AND MATERIALS

#### 3.3.1 Case study research approach

A case study research approach was chosen that can either involve a single or multiple case studies (Yin, 1994). I have chosen to do multiple case studies with
two study sites, and thus will report on the different results in a journal article format. I have chosen this type of approach because (1) case studies are a process orientated method that help the researcher understand why certain things do or do not occur, (2) various methods that study the context of the phenomenon are conducted, and (3) to investigate the phenomenon under study by making use of triangulation; which is the use of multiple sources to validate data collection. These various methods include interviews, surveys, and observations (Meredith, 1998). This approach was beneficial to the study because, I focussed on people’s experiences, observations and actions. I assessed how climate has changed over the past years, what measures the people are taking to adapt to these changes, and why those measures are undertaken. In order to understand the farmers’ actions and why those actions are employed, I needed flexible data collection methods that allow context, complexity, and details (Mason, 2002). Trust had to be built between the farmers and the researcher, in order for farmers to provide detailed information. Thus, I used key informants that have been working in the study areas previously and are trusted by the farmers to assist me with data collection.

To contextualize a phenomenon, a case study approach allows the addition of the why question, to the already existing what and how questions (Meredith, 1998; Yin, 1994). It also allows a greater immersion in the chosen area(s), providing the researcher with deepened understanding and appreciation of local dynamics and decision-making (Lebert, 2005). A variety of methods can be used in a case study, through triangulation. Each of these methods produces different but corresponding data, therefore resulting in higher quality research outputs (Swarts, 2015).

3.3.2 Sample selection

Instead of formulating hypotheses, qualitative research deals with investigating meaning behind an event. Methods conducted in this research are labour intensive, and analyzing a large sample size can be time-consuming and often impractical. However, the sample size chosen needs to be large enough to ensure that most insights relevant to the research topic are uncovered (Mason, 2010).
From literature, authors suggest a minimum of 20 (Creswell, 1998) to a maximum of 60 respondents (Bernard, 2000; Morse, 1994) as sufficient sample sizes.

The sample size for each of the two study sites was chosen to be the minimum of 20 livestock farmers, as suggested in the literature. The group targeted for the study were livestock farmers who farm with goats, sheep and cattle farmers.

3.3.3 Data collection

Data collection was conducted from March 2014 till August 2015. Methods to assess the livestock farmers’ knowledge on climate change and variability and indicators they use for monitoring purposes and adaptation strategies were: (1) a pilot phase followed by (2) focus group discussions, which were then followed by (3) semi-structured interviews.

Pilot phase

For Leliefontein village and Steinkopf, people who have done research in the area were used as key informants. Literature was also used as additional material. Key informants and literature were used to get a background of the area, and how farmers manage their livestock. From this background information, draft questions were prepared and five randomly chosen farmers were interviewed to test the relevance of the questions. For the Leliefontein village, this pilot phase was conducted from 31 March to 04 April 2014. The pilot phase for Steinkopf Communal Area was from 26 to 30 January 2015. The responses from the respondents were then analyzed for additional information that was not known before the study.
**Focus group discussions**

The additional information from the pilot phase led to the construction of a focus group discussion. From the focus group discussion, the researcher is able to get quick shared practices, memories or ideas from the community rather than having to do numerous one-on-one interviews to discover the shared information (Kamberelis and Dimitriadis, 2011). There are several assumptions of focus groups. One of the most common assumptions is the probability of a few respondents out of the whole group dominating. However, this is where (Mason, 2002; Yin, 2004), states that it depends on the good facilitator to carry out a productive discussion. On the other hand, Kamberelis and Dimitriadis (2013) regard focus groups as advantageous because some people can be reluctant to answer questions during one-on-one interviews. This is because the topic may be sensitive or the person has a bad memory attached to the topic or simply because the person thinks, their information is not valuable to the question. Focus groups are thus known to break this personal discomfort (as most farmers in this study are related), and respondents are free to voice out their experiences which might be shared in a group.

A total of 10 and 14 livestock farmers participated in focus group discussions in Leliefontein village and Steinkopf Communal Area respectively. In these two areas, the focus group discussion was based on a seasonal calendar. The purpose of the seasonal calendar was to obtain information on climatic and environmental changes farmers have observed, indicators they use to monitor seasonal change, and how they use local knowledge for actions they take to adapt to the changes they experience. Barbour (2007) states that focus groups can provide the researcher with new ideas or theories that were not initially thought of in the beginning of the study. This was evident in this study, where the theme of the impact climate change and variability has on livestock diseases was added to the study. Analyses of the focus group discussions led to the construction of an in-depth open-ended questionnaire.
**Semi-structured interviews**

A semi-structured questionnaire was used for in-depth semi-structured interviews (see Appendix A). The questionnaire consisted of different sections that included demographics, local understandings of climate change, observed changes in rainfall, temperature and wind, environmental changes, adaptation strategies, livestock diseases and local knowledge transfer. Suitable interview times were arranged with the farmers. All interviews were conducted in Afrikaans, and were recorded with a tape recorder in order to later translate them to English. All respondents were given an information sheet that explained the purpose of the study, their participation and consent form to read and sign before the interview was conducted. A set of theme related questions were used to stimulate the conversation for the interview, which was conducted for a maximum time of an hour. A snowballing method was used for interviews; where respondents referred the researcher to other farmers that can be interviewed. Interviews were conducted until saturation was reached for each area. A total of 20 farmers in each of the study sites were interviewed.

### 3.3.4 Data Analysis

ATLASi was the qualitative data analysis software used to analyze the data. All respondents for each area were grouped according to age and farming experience. The analysis included grouping respondents’ answers according to pre-thought themes and new emerging themes. Pre-thought themes were local understanding of climate change and variability, sources of climate change information, observed changes in climate variables and adaptation strategies which included transhumance and supplementary feed. New emerging themes were identified as climatic and non-climatic barriers to adaptation.
CHAPTER FOUR: LIVESTOCK FARMERS UNDERSTANDING OF CLIMATIC CHANGES WITH ASSOCIATED IMPACTS ON RANGELANDS

4.1 Introduction

Indigenous knowledge systems, which have been developed over centuries, are an important component of pastoral livelihoods (Wiid and Ziervogel, 2012; Ghorbani et al., 2013; Fernández-Llamazares, et al., 2016) and aides in rural development and community resilience to climate change and variability (Agrawal, 1995). However, its efficiency is questioned as climate change will bring about new conditions that pastoralists have not experienced before and uncertainty regarding future changes (Midgley et al., 2005; IPCC, 2007; Bourne et al., 2012), thus they may not have sufficient knowledge to cope and adapt to climate change and variability. For the purpose of this study, the indigenous knowledge system is based on Local Ecological Knowledge, which is defined as the knowledge generated from observations and human-environment interactions that evolve by adaptive processes from a specific area (Dudgeon and Berkes, 2003). This local knowledge influences the people’s understandings and perceptions on incidents that occur in their locality.

Various studies on livestock farmers’ understanding and awareness on climate change and variability exist (Idrisa et al., 2012; Harmer and Rahman, 2014; Teshager, 2014) but not specifically amongst smallholder farmers (Kempton, 1997; Madziwa et al., 2013). A South African example is a study by Muller and Shackleton (2003) which found that communal livestock farmers in the Eastern Cape Karoo had little or no understanding of the climate change or global warming phenomenon. The reason of the lack of understanding of the farmers was based low levels of literacy. Low levels of literacy are commonly argued as the main source of the lack of climate change and variability understanding amongst farmers in other developing countries (Muller and Shackleton, 2013, Fatuase and Ajibefun, 2014). However, there are examples of high awareness levels in some
African countries amongst communal farmers (Maddison, 2007; Chagutah, 2010; ZBC, 2012).

Kempton (1997) adds that people need to have detailed climate change and variability knowledge in order to have sentiments on the matter. Climate change and variability knowledge reduce the dangers of farmers making mistakes in their decision making for adaptation strategies (Saloranta, 2001). Various other studies conducted in Africa (Okonya et al., 2013; Simelton et al., 2013; Moyo et al., 2012; Gbetibouo, 2009; Maddison, 2007) indicated that adaptation strategies utilized by farmers depend on their perceptions of climate change and variability.

Perception depends on the environment and its features (Heathcote, 1969), people’s age, experience, gender, geographical location, knowledge on the environment and weather (Roncoli et al., 2002; Slegers, 2008). Farmers are more likely to notice and keep a record of changes in climate when they have more farming experience (Maddison 2007). Since ancient times, African communities and pastoralist in semi-arid and arid regions have used local knowledge based on their observations and experiences to understand weather and climate patterns in order to cope with their changing environments (Bello et al., 2013). Other factors that might influence farmers perceptions include socio-economic impacts on livelihoods. These are influential because they are essential in decision-making on climate change and variability adaptation (Slegers, 2008). Culture is believed to be one aspect of the social settings shared by individuals within the same geographical location, thus creating norms and general farming style that is often accepted by the members of the community (Slegers, 2008). However, this does not mean that all farmers in that community will have an identical mode of production because each farmer has their own production goals, farming knowledge and abilities (Slegers, 2008) which can influence their perception.

Several studies (Hassan and Nhachena 2008; Thomas et al., 2007; Fatuase and Ajibefun, 2014; Varadan and Kumar, 2014) that have been conducted to examine farmers perceptions of climate change and variability by showing how farmers in different or the same countries have diverse perceptions of climate change. People
have different views and perceptions due to their experience, age, location, beliefs and sources of information.

Even though pastoralists live in harsh and climatically variable environments (Bekele and Asmalu, 2012), they still manage to continue with their traditional ways of keeping livestock (Harmer and Rahman, 2014). The continuation of the pastoralists’ traditional ways despite the challenges they face, is sustained by their rich local knowledge (Khan and Roberts, 2013). Namaqualand farmers in South Africa are known to have ecological knowledge that has been the core factor to their management strategies (Debeaudion, 2001) but there is a lack of understanding of their knowledge regarding climate change and variability adaptation.

The aim of this study was thus to assess livestock farmers’ knowledge on climate change and variability and associated environmental changes. This study also aims to compare local narratives from livestock farmers with meteorological records of climate change and variability in the two communal areas in the Namaqualand region, with the perceived impacts climate change has on livestock farming.

This chapter attempts to answer the following questions:

1. Are livestock farmers from Leliefontein village and Steinkopf in the Namaqualand region familiar with the phenomenon of climate change and what does it mean to them?
2. What are the different sources of information on climate change and variability used by communal farmers in Namaqualand?
3. What are the perceived climatic changes that have occurred in the Leliefontein village and Steinkopf during the farmers’ lifetime, and are these perceptions validated by scientific data?
4. What are the different indicators that livestock farmers in the Leliefontein village and Steinkopf use to monitor changes in weather and climate?
5. What are the perceived climate change and variability impacts on communal livestock farmers from climatically different areas?
4.2 Methods and materials

Detailed methods and materials are discussed in chapter 3. For this chapter, I will focus on the farmers’ knowledge and observed climatic and environmental changes sections in the questionnaire (Appendix A). Due to the interviews being semi-structured, there were instances where follow up questions which are not included in the questionnaire were asked.

Scientists often use the term climate change for technical reasons (Leiserowitz et al., 2014), but does this definition resonate with livestock farmers in rural areas? In this study, I was required to determine whether the farmers’ interpretation of climate change is similar to the definitions used by scientists. For this comparison, literature was consulted to determine the globally accepted definition of climate change.

Perceptions and values of peers within the same community can influence other farmer’s perceptions (Maddison, 2006). Thus, it was necessary for this current study to conduct one-on-one semi-structured interviews with the farmers. The snowballing method used for the interviews; where respondents referred the researcher to other farmers that can be interviewed. Interviews were conducted until saturation was reached for each area. A total of 20 farmers in each of the study sites were interviewed.

In order to understand farmers’ perception towards climate change in Leliefontein village and Steinkopf communal area, farmers were asked to indicate their perceived observations with regard to long-term changes in temperature and precipitation in their relevant areas. Livestock farmers from the two study sites were asked about local temperature, rainfall and wind changes they have experienced over time (see Appendix A). In order to identify the indicators in the study areas farmers had to name and explain (if any) indicators that they use to forecast/predict or interpret rainfall or environmental changes.

It is often assumed that farmers with a high number of farming years’ experience hold the wealthiest knowledge about events that have occurred during that experience (Maddison 2007). In order to assess this difference, I used farming
experience to conduct Chi-Square tests in order to test for significant differences in knowledge and observed changes between farmers.

In addition to the quantitative data, historical meteorological data was used to examine the study’s aim. The historical climatic data from the nearest weather station for each of the study sites (South African Weather Services) was analyzed and compared with farmers’ perception of climate change and variability. Climatic records of a 100-year period (1915-2015) were analyzed in order to show long-term rainfall changes. These data were used to compute above or below the annual temperature (minimum and maximum) and rainfall. Most studies on the farmers’ perceptions of climate change often refer only to rainfall records, however, this present study considers both rainfall and temperature records. A decade (2002-2012) was used for Leliefontein village since it was the only actual data available. Temperature data from 1980 till 2015 was used for Steinkopf since farmers perceived the 1980s as the past. Temperature trends were computed using winter (Jun-Aug) and summer (Dec-Feb) months with five-year moving average trend line.

4.3 Results

4.3.1 Farmer’s interpretation and knowledge on climate change and variability

When farmers were asked if they were aware of the phenomenon climate change, all of them from both study sites indicated that they are aware of it. Differences arose when farmers were asked to explain their understanding of the phenomenon. Ten percent and 45 % of livestock farmers in the Steinkopf commonage and Leliefontein village respectively indicated that the concept climate change is difficult to explain. The Steinkopf farmers who had difficulties in explaining climate change indicated that they did not see climate change as a serious problem that needs urgent attention. These farmers see climate change as something that has been happening for centuries and believe that they can handle it. On the other hand, the Leliefontein village farmers who could not explain the phenomenon
indicated that even though they cannot explain what climate change is, they recognize its impacts and the need for adaptation. Examples of responses from both study sites were as follows:

“I’m not much concerned about that if rain comes it comes. You know there are four seasons, so you adapt to changes. Nothing you can do about that.”

-Steinkopf farmer

“Yes many people talk about climate change on the TV about what must be done, but I do not know what it is, or how to explain it.”

-Leliefontein village farmer

The remaining 90% and 55% of the farmers interviewed in Steinkopf and Leliefontein respectively could explain the phenomenon. Of the Leliefontein and Steinkopf farmers that had an understanding, their understanding resonated more to “seasonal shifts” or associated the climate change phenomenon to seasonal shifts that they have been experiencing.

“The seasons are not what they used to be. It’s more of a seasonal shift than climate change because when we expect the flowers to blossom, it rains and when we expect it to rain, the flowers blossom. Like now (September), it’s supposed to be spring now but look how the sky looks, it’s cloudy.”

-Leliefontein village farmer

When these farmers gave their understanding of climate change as ‘seasonal shift’, their definition of the phenomenon was similar to that of climate change scientists (Textbox 1).
Climate change is when there are weather changes, where the weather varies from the norm either in a day or during seasons. This variation is in temperature and rainfall. “

-Leliefontein village farmer

“A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use”

-IPCC 2014

Since the farmer’s agricultural practice is dependent on climatic variables such as rainfall and temperature, they prefer to associate the climate change to seasonal shifts as an indicator for climatic changes that have been occurring and affecting their farming practice. Even though the farmers have diverse understandings of climate change, their knowledge captured the essential components about the phenomenon and its expected changes. When explaining their understanding of climate change, their explanations were based on observed shifts in seasons and changes in climate variables they have experienced in their lifetime.

Comparing the IPCC definition with that of farmers, it is clear that both definitions focus on changes in climate variables over time. These climate variables included changes in temperature, rainfall, and wind and overall shifts in seasons. However, from the farmers definitions, it was evident that the time scale they use is seasons instead of decades or centuries, as compared to the international definition.
4.3.2 Source of information and understanding

The farmers’ understandings of climate change or seasonal shift as they refer to it stem from various sources. The most common information sources for Leliefontein village and Steinkopf farmers are the knowledge transferred from their parents or grandparents, attending farmers’ meetings, and social interactions with other farmers (Figure 4.1). Apart from informal interactions, farmers in Leliefontein village acquired information through attending workshops, farmers’ meetings, television, and radio. Workshops attended by Leliefontein farmers are often organized by non-profit organizations or parastatals. It is shown in figure 4.1 that only Leliefontein farmers mentioned farmer meetings as a source of information.

![Figure 4.1: Sources of climate change information used by Leliefontein village and Steinkopf livestock farmers.](http://etd.uwc.ac.za/)

Even though not represented in the questionnaire used but from observational methods, farmers from both Leliefontein village and Steinkopf also use print media (newspapers and farmer’s magazines) as sources to enhance their climate
change and adaptation information. As an example, *Die Veepos* (Figure 4.2) is a free local newspaper written in the Afrikaans, the local language, with climate and environmental information that is distributed to the two study areas. A noticeable finding for this study was agricultural extension advice was not mentioned as a source of information for both Leliefontein and Steinkopf farmers.

**Figure 4.2:** Namaqualand local newspaper (*Die Veepos*) with various articles written in an easily understandable language (Afrikaans) to Leliefontein village and Steinkopf livestock farmers. Source: *Die Veepos* May 2016.

### 4.3.3 Perceived climatic changes

Leliefontein village farmers have been farming since their childhood years and the majority of them have over 30 years farming experience thus, have noticed several climatic and environmental changes over decades. The majority of Steinkopf farmers have less than 15 years’ experience (Table 4.1). The Chi-Square analysis of farmers’ experience between the two areas was significant ($\chi^2 = 14.035, p = 0.003$).
Table 4.1: The frequency of livestock farmers’ farming experience for Leliefontein village and Steinkopf areas.

<table>
<thead>
<tr>
<th>Farming experience (years)</th>
<th>Time period from</th>
<th>No of farmers</th>
<th>Steinkopf</th>
<th>Leliefontein</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 5</td>
<td>2011 - present</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6 to 17</td>
<td>1999-2010</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>1987-1998</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>&gt; 30</td>
<td>pre 1987</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

A wealth of information was given by the respondents when they were asked if and how has the seasons shifted over the time. The majority of the farmers from Leliefontein village and Steinkopf described shifts in seasons based on weather conditions. These generally included the amount and distribution of rainfall during the rainy season and the predominant temperatures within a given season. For Leliefontein village, an overwhelming 80% of farmers indicated that seasons have shifted. Occurrences of seasons, especially winter have shifted forward at least by two or more weeks. The remaining 20% stated that the seasons have remained the same. Similarly, 75% of Steinkopf farmers indicated a shift in season, while 10% of them indicated no change and 15% were uncertain. However, it is important to note that when these farmers were further asked to explain their response; I noted that they were aware of the two-week delay, but considered this to be insignificant.

Using seasons as a reference, farmers mentioned how changes in climate have changed over the years that they have been farming.

(a) Temperature

Interviewed and focus group discussion farmers agreed that temperatures have decreased during the winter season, and increased during the summer season. Figure 4.3a respectively shows a 10-year trend in average temperature for the hottest and coldest months as representatives of the summer and winter temperatures for Leliefontein village.
It is clear from the trend in figure 4.3a that winter temperatures for Leliefontein village started to decrease in 2011. The five year moving average for Leliefontein village also shows that a decrease in winter temperatures started in 2011.

**Figure 4.3a:** Mean temperatures for summer and winter seasons from 2002-2012 with a five-year moving average trend line for Leliefontein.

Figure 4.3b shows that winter temperatures for Steinkopf decreased since 2000 and started increasing in 2007 till 2010. When we look at the five-year moving average, winter temperatures have decreased since 2011. The five-year moving average shows that summer temperatures for Steinkopf increased since 2004 till 2010. This increase was followed by a slight decrease which stabilized till 2015.
Figure 4.3b: Mean temperatures for summer and winter from 1990-2015 with a five-year moving average trend line for Steinkopf.

(b) Precipitation

Interviewed farmers mentioned that rainfall during the winter season has shifted and decreased. Farmers from both study sites agreed that rainfall and seasons were more predictable in their youthful years, which they considered being the 1980s. For the current study, Leliefontein farmers noted that the winter season characterized by the onset rains used to start at the end April or beginning of May, but now tends to start in June. This was similar in Steinkopf where farmers also indicated the start of their onset rains were characterized by an eight-day rain period which occurred in April/May; which is now absent.

One respondent from Steinkopf also indicated that over the past five to six years, rains fall for a shorter duration with higher intensity. When comparing the recorded rainfall data for the past 40 (1975–2015) years with the perceived changes mentioned by Leliefontein and Steinkopf farmers, there is an agreement with year-to-year variability (Figure 4.4 and 4.6). Interviewed farmers from both study sites also reported decreases in annual rainfall. However, the five-year moving average did not show this reduction in rainfall amount (Figure 4.4). On
the other hand, the five-year moving average for the last five years from 2010–2015 shows that rainfall amounts in Steinkopf has decreased (Figure 4.5).

Figure 4.4: Leliefontein total rainfall from 1975–2015 with five-year moving average trend line (South African Weather Services, Unpub. data).
Further analysis of above or below mean annual rainfall indicates that droughts are frequent in both Leliefontein and Steinkopf with a 100-year period from 1915-2015 (Figure 4.6 and 4.7). These graphs also show that some droughts were multi-year droughts. This suggests that farmers in both study areas experienced multi-year water scarcity.

Namaqualand livestock farmers generally defined drought as the lack of rain during the rainfall season. According to the South African Weather Services data, Leliefontein has experienced multi-year droughts lasting over three years (e.g. 1926-1933 and 1978-1982) (Figure 4.6). On the other hand, Steinkopf has experienced multi-year droughts that lasted for five years (e.g. 1936 – 1939 and the 1969 -1973) (Figure 4.7).

For this current study, Leliefontein livestock farmers recalled the occurrences of droughts in years 1978, 1998, late 1999/early 2000s, 2003, and the most recent one of 2014/15 (Figure 4.6). Steinkopf livestock farmers, on the other hand, had remembrance of between 1967/68, 1969, between 1970/72, 2003-2004, and also...
the recent 2014/15 (Figure 4.7) being drought years. According to both figure 4.6 and 4.7, the farmers’ memory was accurate for those drought occurrences.

**Figure 4.6:** A 100-year period above and below annual average rainfall for Leliefontein village (South African Weather Services, Unpub. data).

**Figure 4.7:** A 100-year period above and below annual average rainfall for Steinkopf Communal Area (South African Weather Services, Unpub. data).
(d) Wind

Farmers interviewed indicated that the wind is another climate change variable that has not remained the same over the past years. A total of 58% and 80% of Leliefontein and Steinkopf farmers respectively indicated that the wind has changed over the past years. All interviewed farmers were in agreement that August is their windiest month; however, recently they sometimes receive the wind any time of the year, with variation in velocity and direction. When farmers were asked how the direction, speed, and season of wind have changed, their responses differed between the two study areas. Of the farmers in Steinkopf that had indicated that wind has changed, 50% of them were not certain with the specifics of how wind has changed, while 42% highlighted that the wind is not as strong and frequent as it used to be in the past, and only 8% indicated the wind is now stronger and more frequent. Farmers also made reference to eight days of wind of strong winds that indicate a change of season that are no longer occurring.

Fifty-seven percent of Leliefontein farmers that indicated that the wind has changed highlighted that the intensity and frequency of winds has increased, while 43% indicated they were uncertain of the specifics. Figure 4.8 shows that the lowest recorded wind speed for both Leliefontein village and Steinkopf was in the year 2013. This might be the reason why some farmers in Steinkopf perceived weakened wind intensities, as the period was recent and fresh in their memory.

Variations in wind velocity are subtle in Steinkopf and farmers only notice large changes in the wind when it affects their water provision. These farmers rely on windpumps for water extraction for their animals. For example, respondents in Steinkopf recollected a time in the 2000s, when the wind wreaked havoc on buildings and infrastructure in the area and the scars are still visible till this day.
4.4 Indicators used to monitor climatic change

Based on their local knowledge, farmers from Leliefontein village and Steinkopf use various indicators to monitor changes in climate variables. A summary of these indicators is presented in Table 4.2. Four major categories were developed based on the traditional weather forecasting and climate prediction indicators related to rainfall conditions as derived from interviews with farmers, and as follows:

- Meteorological
- Livestock behaviour and condition
- Livestock diseases
- Flora and Fauna

Figure 4.8: Daily average wind speeds from 1980-2015. (Sourced from: African Flood and Drought Monitor).
### Table 4.2: Local indicators used by Steinkopf and Leliefontein communal livestock farmers for weather forecasts and to monitor climatic changes.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description of indicator</th>
<th>Expected changes in weather/climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteorological</td>
<td>More frequent and strong winds (Leliefontein).</td>
<td>Decrease in rainfall</td>
</tr>
<tr>
<td></td>
<td>Occurrence of a southerly wind during winter season (Leliefontein)</td>
<td>Snowfall occurrence</td>
</tr>
<tr>
<td></td>
<td>Easterly winds (Leliefontein)</td>
<td>Black frost occurrence</td>
</tr>
<tr>
<td></td>
<td>Southern wind that blows more frequent (both study sites)</td>
<td>Lack of rainfall</td>
</tr>
<tr>
<td>Livestock behaviour and condition</td>
<td>Miscarriages or abortions during the lambing season (both study sites)</td>
<td>Prolonged dry season or drought</td>
</tr>
<tr>
<td></td>
<td>Livestock moving to warmer low altitude areas (Leliefontein)</td>
<td>Extreme coldness and commencement of rainy season</td>
</tr>
<tr>
<td></td>
<td>Cattle and goats flap their ears together, jumping around of small stock, “mating” of Boer goat ram (both study sites)</td>
<td>Rainfall occurrence</td>
</tr>
<tr>
<td>Livestock diseases</td>
<td>Livestock having pneumonia (Leliefontein)</td>
<td>Extreme coldness</td>
</tr>
<tr>
<td>Flora and Fauna</td>
<td><em>Calobota sericeae</em> (fluitjiebos) starts to flower (Leliefontein)</td>
<td>Indication of winter season approaching</td>
</tr>
<tr>
<td></td>
<td>Fast movement of termites (both study sites)</td>
<td>Rainfall occurrence</td>
</tr>
<tr>
<td></td>
<td>Movement of snakes to mountains (both study sites)</td>
<td>Rainfall occurrence</td>
</tr>
<tr>
<td></td>
<td>Horses tend to be noisy (both study sites)</td>
<td>Rainfall occurrence</td>
</tr>
</tbody>
</table>

http://etd.uwc.ac.za/
4.4.1 Meteorological

Wind: The overlooked part of climate change

The most dominant meteorological indicator in both Leliefontein village and Steinkopf identified by farmers was wind. The meteorological indicator identified by Steinkopf farmers is the occurrence of an easterly wind. This wind is an indication that they need to move to Bushmanland as rain is about to fall there. Also, another farmer mentioned that when frost is accompanied by wind, this serves an indication that the veld will become dry for a certain period. In the Kamiesberg Mountain, (Leliefontein), farmers noted that a southerly wind during winter can be an indication that snowfall might occur. However, this is not an indication of the amount of snowfall that will fall or the duration.

4.6.2 Livestock behaviour

Farmers rely on animal behaviour and livestock condition to assess climate and forage quality in the area. During the winter season characterized by very cold temperatures in Leliefontein village, livestock often moves on their own to warmer areas, especially lower altitudes.

Livestock condition indicators include low animal production brought by frequent abortions from goats as a sign of water and forage scarcity and most often a drought. Miscarriages or abortions during the lambing season (May to June) for small stock were reported by the farmers from both study sites. This is a crucial indicator for the farmers as it provides them with an indication of their production and growth of their herd.

In both the study sites, joy (jumping around) among livestock, particular goats and sheep is an indication of expected rainfall. It has profound meaning if the jumping takes place when the livestock return to the kraal or at night. According to the respondents, cattle and goats also tend to flap their ears to indicate that the rainfall season is forthcoming. The playful nature among livestock is also regarded as an important indicator for rain for respondents in the study areas. One
farmer in Steinkopf stated that the Boerbok ram will only mate when he knows rain is about to fall.

4.4.3 Livestock diseases

Livestock farmers from both study areas in the focus groups and interviews highlighted a number of diseases that they have observed may directly or indirectly be linked to climate change and variability. Tick-borne diseases (e.g. tick-bite fever/bosluiskoors) from mostly blue ticks (Rhipicephalus spp.), brown ear ticks (Rhipicephalus spp.), bont-legged (Hyalomma spp.) and red-legged (Rhipicephalus spp.) ticks are usually rife due to tick numbers increasing during the summer months. Respondents highlighted how the recent 2014/15 drought exacerbated the number of ticks in their respective areas. Farmers highlighted that during long dry spells they have to do daily checks for ticks up until the winter months.

However, Steinkopf farmers acknowledged that certain diseases may not be related to climatic conditions, but could be a result of the genetic make-up of the animal. As one farmer articulated it,

“In our area, I’ve observed two diseases that I had not known about or have not experienced in the past that is rabies and bloednier (pulpy kidney). But these can be genetic and not climate change related. Recently the Department of Agriculture has bought 10 new goat rams for us to use in our area, but the genetics and how they look differ or …either that or those rams were really in a bad condition”

-Steinkopf farmer.

4.4.4 Flora and fauna

A change in plant phenology, especially the flowering of Calobota sericeae (previously known as Lebeckia sericea) was also mentioned by Leliefontein farmers as an indicator for a start of the winter season. Termites, snakes, and
horses were the other animals that respondents referred to indicators. Respondents highlighted that when sensing an upcoming rain, termites tend to move fast in multitudes in order to store food to avoid famine. Other respondents mentioned the upward movement of snakes to the mountains as an indication of rainfall which indicates the commencement of the wet season.

4.5 Perceived climate change impacts on livestock farming and associated environmental changes

When farmers were asked to indicate their perceptions on major and environmental change impacts they are currently experiencing at the local level to their livestock farming practice, similarities and differences arose between the two study areas. Through the interviews, livestock farmers explained how the current weather patterns are affecting their farming systems and subsequently their livelihoods. Colder night temperatures during the winter months which result in livestock mortality were mentioned as a major threat by farmers from both study areas. Another major concern to Steinkopf farmers was the impact of water and forage reduction that further reduces the livestock’s health condition.

4.5.1 Increased rainfall unpredictability and variability affects livestock management practices

The shift in the onset of rains from April to June affects the lambing season because it prolongs the dry season. The shift in seasons affects the lambing season and lamb mortalities increase as a result of decreased milk production of the ewes. The high variability of some years receiving little or more rainfall affects farmers’ abilities to plan and make farm related decisions. One farmer in Steinkopf reported the following:

“It influences the lambing percentage. If rain comes too late, your lamb does not have milk for a longer period. So our lambs are not in good condition when you want to sell them, you have to almost keep it for two

http://etd.uwc.ac.za/
months longer before it will reach the weight to sell it at a good price”
- Steinkopf farmer.

The unpredictability of rainfall in both areas also affects the farmers’ transhumance and food availability for livestock. If plants that do not receive enough rainfall to grow, there would be limited availability of forage for farmers. In cases where rainfall unpredictability is to increase, it could pose a threat to transhumance which is season dependent, and it could lead to higher livestock mortalities.

4.5.2 Decreased forage availability

Farmers from both study sites also reported limited forage availability during summer as an additional impact of climate change. A decrease in forage availability was listed as a consequence of a lack of rain with increasing maximum temperatures. Figure 4.9 shows during which periods of the year farmers proclaimed they have shortages of livestock forage. In general, forage availability varies throughout the year, and normally reaches its low levels during the dry season.
Figure 4.9: Impacts indicated by Leliefontein village and Steinkopf farmers as the main effects of climate and environmental change to their farming practices.

Farmers in Leliefontein village also reported a decrease in forage availability as a result of changes in wind frequency and intensity. Towards the end of winter season, in August, an easterly wind normally blows in the Namaqualand area. Farmers in Leliefontein village indicated that this wind is stronger and it blows more frequently than before. The increase in the intensity and frequency of this wind results in rain clouds being blown away, thus, might be one of the factors of less and unpredictable rainfall in the area. Not only does the direction of wind take these rain clouds away, but the strong and frequent winds dry up the annual plants and decrease their abundance in the area. During the spring season, most livestock farmers in Namaqualand are dependent on annual plants that grow in his area as forage for their livestock. Farmers described these annual plants as forage that can sustain livestock for preferably a quarter of the dry season. As a consequence, to the strong winds, forage availability decreases in their rangeland, thus affecting livestock’s condition. Apart from annuals, the easterly winds in Leliefontein village bring black frost that decrease forage quality. As one of the farmers related,
“Black frost comes with the easterly winds. This frost makes plants become green as you might think that the veld is good but when you break the plants they are dry inside”

-Leliefontein village farmer

4.5.3 Reduced water availability leading to vegetation changes

Steinkopf farmers regarded water scarcity, especially during summer or during a drought as the main impacts to livestock. The farmers reported water scarcity as one of the main drivers of vegetation changes in the area. They reported that less availability of water in the area propels them to use and overcrowd the few functional water points in the area. As a result of this overcrowding, overgrazing occurs mostly to the areas surrounding the water point, thus changing the vegetation. Overgrazing was reported by the farmers from both study areas as a factor that often results in dominance of unpalatable plant species. According to the farmers, there is an increase in the dominance of unpalatable plants, especially renosterbos (*Elytropappus rhinocerotis*) and kraalbos (*Galenia africana*) in Leliefontein and mostly *G. africana* in Steinkopf. Interviewed farmers thus concluded that a combination of drought and overgrazing is as a major driver of vegetation change in Steinkopf. Both these factors are related, where overgrazing worsen the drought situation by removing the little forage left in the environment.

4.5.4 Impacts of drought on livestock production

During 2014-2015, South Africa experienced a drought, and Namaqualand livestock farmers were severely affected. Farmers reported that prolonged dry periods and droughts are often followed by extreme cold temperatures that result in animal losses, and some farmers in Steinkopf lost more than 60 individuals of their livestock due to the cold temperatures (Figure 4.10).
4.5.5 Increased occurrences of existing diseases and emergence of new ones

Farmers from both study sites indicated that these diseases are not new; however, their incident frequency has increased. However, there were instances were Leliefontein village farmers reported that there is an occurrence of unfamiliar diseases and symptoms. To counteract the already expensive medication to treat their livestock, farmers from both Leliefontein village and Steinkopf indicated that they sometimes use traditional and household remedies to treat diseases.

4.6 Discussion

4.6.1 Climate change awareness and understanding amongst livestock farmers in Namaqualand

The high percentage of climate change awareness and understanding found in Leliefontein village and Steinkopf is similar to results found by Lebel et al. (2015), where 91.8 % northern Thailand fish farmers were aware of the
phenomenon. However, they differ with a South African study (Muller and Shackleton, 2013), where Eastern Cape Karoo commonage farmers were found to have little awareness and understanding of climate change.

The climate change phenomenon has also left confusion and uncertainty in both the scientific and public community (Etkin and Ho, 2007). This confusion has mostly been a result of the jargon that is often associated with climate change explanations and interpretations. This was highlighted in a recent study by Ndhlovu and Mpofo (2016), where interviewed Zimbabwean communal farmers conveyed their concerns with the jargon used in media that made it difficult for them to adapt because they do not understand the words used.

This current study also found that Steinkopf farmers do not recognize the urgent attention of climate change and variability. This is in line with recent work on climate change perceptions that found that people often perceive it to be a distant problem that they cannot control (Spence et al. 2012; Niles et al. 2015). Beliefs of having no control include spiritual beliefs of God’s plan, and nature trying to punish humans for not taking care of it. Attributing these beliefs is consistent with findings from similar studies in Eastern Cape Karoo (Muller and Shackleton 2013), and Zambia (Nyanga et al., 2011). It can thus be said that spiritual beliefs shape the beliefs of commonage farmers (Muller and Shackleton 2013). This might be attributed to the closeness these farmers have with nature, by depending on natural resources to sustain their livelihoods.

The Leliefontein village and Steinkopf farmers’ understanding of climate change is associated to seasonal shifts that they have been observing overtime. Thus they would prefer to use the concept of seasonal shifts when communicating about climate change. Even though these terms might be different, they are related since seasonal shifts are a result of climate change. Additionally, when the farmers gave their understanding of ‘seasonal shift’, their definition was similar to that of climate change used by scientists, therefore highlighting the relatedness of these terms. According to Leiserowitz et al. (2014), in their book ‘What is in a name: Global warming vs. Climate change’, their studies found that for the American public, global warming and climate change are often not synonymous. The terms
mean different things to different people and activate different sets of beliefs, feelings, and behaviours, as well as different degrees of urgency about the need to respond. This ultimately relates to jargon, where one thing can be called by different names by different people in different places. Scientists often prefer the term climate change for technical reasons, but should be aware that the term generates different interpretations among the general public and specific subgroups (Leiserowitz et al., 2014). This supports a statement made by Peters (2012) stating that scientists and non-scientists do not understand each other’s language.

4.6.2 Sources of climate change and agro-ecological information

Livestock farmers in the Namaqualand region are known to possess in-depth ecological knowledge which has allowed them to adapt their management practices (SPP, 2003; Samuels, 2006). Farmers for the current study are descendants of the Nama-Khoi, and farming is a tradition that is passed on from generation to generation. Tradition represents the way people live and knowledge learned from generation to generation. This knowledge is passed down to the younger generation through cultural practices (Simelane, 2005), and in this case, livestock farming. Livestock farmers have over many years accumulated local knowledge that is important for decision making (Berkes et al., 2003). One can, therefore, say that local knowledge is embedded in the people’s practices, experiences and observations (Fernández-Giménez and Estaque, 2012; Ghorbani et al., 2013). People’s experience and observations on changes in weather patterns and extreme weather events have been stated by UNFCCC (2005) as an important source of information and awareness to climate change. In that context, this is essential for those whose livelihoods are dependent on climate-sensitive practices, such as farmers (Mudombi, 2015).

It was found that only Leliefontein farmers reported attending farmers’ meetings as a source of their information. In these meetings, farmers communicate amongst themselves or are provided with information from other external
stakeholders. Farmer to farmer knowledge exchange is vital for the farmers of Leliefontein and Steinkopf. Similar results were found with Seke and Muruwa rural farmers in Mashonaland East Province of Zimbabwe (Mudombi, 2015). Informal farmer to farmer communication is known to be an important information sharing channel (Adam et al., 2015).

Media also plays an important role in informing farmers about climate change (Mandleni, 2011; Ndhlovu and Mpfou, 2016) as it increases abilities of adaptation (Kandlinkar and Risbey, 2000). Weber (2010) indicates that most of the farmers’ knowledge of climate change is indirectly influenced by media. The use of radio has been reported as the most communication medium for climate change in African rural communities (Luganda, 2005), because of its wider reach and compatibility with rural settings (Mare, 2011). It is crucial for the language used to convey information through ICT to be easily understood by the people who access it (Mudombi, 2015). As this is the case with radio and print media in Namaqualand.

Extension advice is a factor that is believed to create awareness to climate change (Maddison 2006; Gbetibouo, 2009; Silvestri et al., 2012) and is also important in information and knowledge transfer mechanism (Mudombi, 2015). Despite farmers from both Leliefontein village and Steinkopf not receiving climate change and variability information from their relevant extension services, these farmers still have an understanding of the phenomenon (Figure 4.1). Similar results were found in a study conducted by Adam et al. (2015) with sweet potato farmers, where extension advice was not received by the farmers, but they had a rich knowledge of crop diseases and management. Consequently, in such cases, farmers often rely on their own knowledge attained through experience and sharing while interacting with other farmers (Adam et al., 2015).

4.6.3 Observed climatic changes

Respondents from both Leliefontein village and Steinkopf understand and perceive changes in their area based on their experiences and how they are
affected by the observed changes. Farmers’ ecological knowledge is not only limited to climate but includes all aspects of the natural environment communities live in.

(a) Changes in rainfall and shifts on wet season: Farmers reporting a shift in the start and end of the rainy season was also found with Zimbabwean (Moyo et al., 2012) and Zambian farmers (Mulenga and Wineman, 2014), where Zambian farmers reported a later start and earlier end to the rainy season. Results of decreases in rainfall amounts and occurrences were found in other studies conducted within African countries (Speranza et al., 2010; Rao et al., 2011; Hartter et al., 2012; Ogalleh et al., 2012; Ndambiri et al., 2013). Respondents for the current study also mentioned a shift in seasons, where the winter season used to arrive in late April but now arrives June/July. Farmers of more than 40 years’ experience in Paulsehoek village also showed similar seasonal shift results in Samuels (2006).

(b) Rainfall variability: The five-year moving average trend line from 2010-2015 show that rainfall amounts in Steinkopf have slightly decreased. This decrease could be the reason why Steinkopf farmers perceive a decrease in annual rain, because farmers’ perceptions are influenced by more recent climate than long-term changes as also evident in other studies (Ferrier and Haque, 2003; Osbahr et al., 2011; Moyo et al., 2012). An additional reason to the difference between the farmers perceptions and historic data could be explained by the fact the weather station used to record Steinkopf’s data is 40 km away from the location of the farmers. Therefore, climatic conditions could differ in 40 km distance. This raises questions about the reliability of farmers’ perceptions, as farmers are believed to fail to differentiate between climate and weather. Moyo et al. (2012) further states that this challenges climate change research, as farmers prefer to use personal experiences instead of statistical descriptions. However, this does not indicate that farmers perceptions are inaccurate and statistical data is accurate, but merely
means that researchers should caution their data sources and triangulate their methods for validation.

The difference between the Leliefontein village and Steinkopf farmers rainfall amount perceptions with the meteorological data indicates that the farmers perceive higher risk than what is meteorologically recorded for their relative areas. This was also evident in a study conducted by Moyo et al., (2012) with crop farmers in semi-arid Zimbabwe. This alert of higher risk can be advantageous where it can influence farmer’s decisions to adapt appropriate strategies (Rao et al., 2011), but it can also be detrimental where farmers feel helpless and believe there is nothing they can do (Grothmann and Patt, 2005). This raises a need for farmers to be informed about the possible adaptations to utilize with the little resources they have.

(c) **Wind:** Leliefontein farmers reported an increase in wind frequency and intensity. Although some scientists (Bogardi and Matyasovszky, 1996; Gregow et al., 2011; McInnes et al., 2011) have projected stronger winds, few have emphasized on changes in the frequency of windy periods (Schwierz et al. 2010; Cheng et al., 2014). Barton (2014) argues that temperature and precipitation are more frequently highlighted in the discussions surrounding climate change, but wind seldom gets the necessary attention despite the fact that global wind speeds have decreased by 5-15% over the last three decades from the year 2004. The wind is created as a result of the differences in temperature and it is expected that wind speed will decrease another 15% in the coming century (Barton, 2014).

The farmers perceived changes in temperature, rainfall, and wind for both current study areas was validated by metrological data. The validity of local knowledge by scientific climate data has been shown by various authors (Vedwan and Rhoades, 2001; Hageback et al., 2005; Cabrera et al., 2006; Newsham et al., 2011). However, there are instances where local knowledge has not been confirmed by quantitative climate data (Roa et al., 2011). Mulenga and Wineman (2014) state that if the two sources of information from farmers and
meteorological records support each other; this would suggest that farmers correctly perceive climate change and variability. In cases where the two sources diverge, this would mean that more research is needed in understanding whether farmer’s perceptions are incorrect or possibly meteorological recordings are not enough to detect aspects of climate change and variability.

4.6.4 Indicators

Due to the challenging and missing information of projections at a local finer scale, local communities believe that the currently available projections are not beneficial to them. Thus local communities have had to rely on their traditional form of early warning system as indicators of expected climatic changes. These are similar to Fernández-Giménez and Estaque (2012), where local communities were recorded to use local warning signs to enlighten them on any change to occur in their area. Indigenous communities use local knowledge of their environment with its resources to develop indicators that enable them to read their environment and tell them if something unusual is happening (Luseno et al., 2002; Marin, 2010; Kagunyu et al., 2016). Indicators known to be used by pastoral communities include wind, clouds and lightning indicators which are rooted in traditional knowledge. These indicators are also used by researchers, however, they are not encompassed under traditional knowledge, but under atmospheric science (Kagunvu et al., 2016). Other people also use the behaviour of livestock, wildlife, and plants as indicators for change. Examples of these recordings exist in Africa (Ovuka and Lindqvist, 2000; West et al., 2008; Rao et al., 2011), Arctic (Nichols et al., 2004; Vlassova, 2006; Laidler et al., 2009; Aporta and MacDonald, 2011), and Asia (Marin, 2010).

The use of meteorological indicators is also evident in Kenya, where agro-pastoralists rely on the use of indigenous indicators to position and interpret meteorological forecasts (Rao et al., 2011). The timing of when will rain fall is an important indicator for pastoral communities as it specifies when to migrate with
livestock (Kagunyu et al., 2016), as accordance with Leliefontein village and Steinkopf farmers.

4.6.5 Impacts of perceived changes

With the uncertainties in climate change impacts on communities at a finer scale, important lessons can be learned from the experiences of farmers in semi-arid environments, since inter- and intra-seasonal and annual variability in rainfall and temperature is something they have coped with for many generations (Mortimore and Adams, 2001; Mertz et al., 2009). Also, these impacts might increase as climate change projections show the western parts of South Africa are to have an average increase of 2-3° C in mean annual temperatures, an increase in rainfall variability and a decrease in mean annual rainfall by 2050 (Midgley et al., 2005). Agricultural practices are one of the most vulnerable sectors to the risks posed by climate change and variability (Gregory et al., 2005; Parry et al., 1999 cited in Ziervogel, 2006; Zampaligre et al., 2014), with distinct negative impacts on livestock productivity. As currently available natural resources and forage quality are expected to decline due climate change and variability (Thornton et al., 2015), livestock farmers need to be aware of climatic and environmental changes (Bele et al., 2014), and how these changes impact their farming practices.

(a) Decrease in water availability

Steinkopf farmers listed a decrease in water availability in their area due to decreased rainfall with increasing unpredictability. Water resources are expected to become scarce especially in areas projected to have reduced rainfall (Amede et al., 2011) and increased temperatures (Thornton et al., 2009; Mandleni, 2011). The mountainous location of Leliefontein village is advantageous to farmers in terms of water availability, where the village receives the most rainfall compared to low-lying areas (Desmet, 2007). This could explain the difference in the
farmers’ perceptions of water availability as the main climate change and variability impact.

(b) Decrease in natural forage in the rangelands

Annual plant abundance is influenced by climate after winter rains (Allsopp, 1999; Helme and Desmet, 2006), thus a change in rainfall patterns may affect the abundance of these plants in Namaqualand. The annuals play an important role in the diet livestock (Steyn et al., 1996; Hendricks et al., 2002; Samuels et al., 2016). These annuals thus form a large diet composition to the livestock (Genin et al., 1994; Samuels et al., 2007; Samuels et al., 2016) due to the nutritional value associated with them (Schoepf and Schradin, 2012). With the projected shifts from Succulent Karoo to a Desert biome (Bourne et al., 2012; Driver et al., 2012) in the Namaqualand region, forage availability can be expected to further decrease (Midgley et al., 2005b, Muller and Shackleton, 2013).

With these projected shifts, livestock farming practice is under threat. Climatic changes leading to a decline of grazing areas and forage resources have been recorded to lower animal productivity in Burkina Faso (Zampaligre et al., 2014) and thus the agricultural potential of the two communal areas investigated in this study is uncertain.

(c) Diseases

Parasites and diseases are amongst the most severe factors globally known to have direct impacts livestock productivity (Perry, 2002). Some diseases affect all regions of the world and all sectors of the community; and some are of importance to individual farmers living in poverty (Rust and Rust, 2013). Over the past few decades, livestock mortalities due to diseases have become a burden on African livestock farmers (Rust and Rust, 2013). The FAO (1990) estimated that animal diseases cause losses up to 30% of the annual livestock production in developing countries.
Various animal diseases are affected by weather and climate, where the climate can alter their distribution, and weather can affect the outbreak timing and intensity of these diseases (Baylis and Githeko, 2008). Projected increases in temperature and variable rainfall patterns are known to likely spread existing livestock diseases (Mandleni, 2011); and in other cases result in the emergence of new diseases (Ahmed et al., 2013). As existing diseases become more frequent, impoverished farmers will likely be the ones most affected with livestock mortalities (Rust and Rust, 2013) as they would need to buy medicine (Mandleni, 2011). Leliefontein and Steinkopf farmers will be mostly affected by these frequent diseases, as they currently live under poverty (Samuels, 2006) and disease treatments requires finance.

Negative effects of diseases on livestock include death, poor weight gain, poor milk yield, poor feed conversion, and poor reproductive capacity. Tick-borne diseases might also impact farmers from both study areas. Tick infestations are known to result in weight loss and reduce milk production in cows (Scholtz et al., 1991), and can sometimes lead to death (Jonsson, 2006). Livestock infested with ticks tend to have a reduced appetite, therefore resulting in weight loss, low milk production and eventually death if left untreated (Jonsson, 2006).

4.7 Conclusion

In conclusion, farmers from both Leliefontein village and Steinkopf indicated the term climate change was new for them but, the phenomenon is something that has been happening for centuries. From the interviews, it was found that the term climate change elicits significantly more associations to seasonal shifts or shifts that farmers have been experiencing. To provide better explanations of their understanding of the concept, the farmers prefer to make use of a local term called seasonal shift, and the definition they provided for it was similar to the IPCC definition. Their understanding is based on knowledge transfer from older generations, media sources, and workshop and meetings attendance. This study shows that farmer to farmer communication is as important to Namaqualand
livestock farmers, as it is with other African farmers. There is a high involvement of NGOs and Parastatal institutions that assist the Leliefontein farmers with the information they need.

Farmers from both study areas have observed a delay in their onset of the rainy season. The duration and amount of rainfall received in both study areas have also decreased. Summer periods have increased in duration over the years with increases in maximum temperatures. High altitude areas such as Leliefontein village have experienced increases in wind frequency and intensity, while low-lying areas such as Steinkopf have experienced weakened winds with decreased frequencies. Rainfall and temperature during the winter season were observed to have decreased.

The perception is that increased wind intensity and frequency in Leliefontein village frequently blow rain clouds away. There is thus a need to investigate the implications that wind changes can have on farming. The reduction in speed and direction directly impacts on the farmers’ daily agricultural activities. A change in wind can bring about no water being extracted, reduction or early loss in annual plants, and increases frost, dew, and snow. The fact that farmers rely on this indicator is evidence that more research needs to be done on its impact on farming. Currently, there is limited literature available on this.

Farmers from Leliefontein and Steinkopf have observed changes in their weather and temperature and rainfall data obtained from the South African Weather Services is similar to their observations. Even though the study sites differ in altitude, observed temperature and rainfall changes between the two sites did not vary. A general concern in the two study sites was the decrease and unpredictability of rainfall that has been congested into a shorter rainy period. The results show that both Steinkopf and Leliefontein have and are still continuing to experience climate change and variability. These changes, therefore, need the farmers to adapt in order for their livestock to survive.

Gradually an increasing number of farmers have perceived that the variation in rainfall is becoming ever more erratic and difficult to predict. Instead of relying
more on environmental, plant and animal behaviour, when making critical
decisions concerning agricultural tasks, interviewees mostly rely on scientific
weather forecast on radio and television. Consequently, their confidence in
local/traditional knowledge is reducing and has led to them seeking and
combining their knowledge with scientific weather forecasts. Despite this, local
knowledge on weather and climate still provides significant value alongside the
scientific forecasts and indicators for change.

As climate change and variability is known to negatively affect the agricultural
sector, livestock farmers from both study sites are aware of its effects that might
threaten their environment and their farming practices. In the next chapter, I will
highlight adaptation strategies practiced by the farmers to overcome the
challenges brought about by climate change and variability with associated
environmental changes.
CHAPTER FIVE: LIVESTOCK FARMER’S ADAPTATION STRATEGIES TO PERCEIVED CLIMATIC AND ENVIRONMENTAL CHANGES

5.1 Introduction

Farming in the semi-arid regions where rainfall variability determines productivity is risky, especially for communal livestock farmers (Rao et al., 2011). Farmers in these areas have to make decisions in order to adapt to the seasonal variability and uncertainty. These decisions are based on their local knowledge, experience, and perceptions gained over the years (Kihupi et al., 2015). The complex management systems developed by these communities assist them in climate change adaptation decision-making relevant to their local environment. The importance of assessing and understanding adaptation strategies relevant to local areas has been widely documented by various studies (Agrawal 1995; Fernández-Giménez, 2000; Davis and Wagner, 2003; Egeru, 2012). Farmers in remote areas especially of developing countries have resigned themselves to fate and believe there are inadequate actions they can take to adapt to climate change and variability (Grothmann and Patt, 2005). This further highlights the need for these farmers to understand that adaptation is possible through their local knowledge, even with the inadequate resources and options available to them.

Perception guides approaches (Maddison, 2007; Gbetiouo, 2009; Kihupi et al., 2015); thus if farmers perceive that changes in climate parameters are occurring and know the associated risks, this will impact on their decisions on how to adapt (Adger, 2005; Silvestri et al., 2012; Muller and Shackleton 2013). Several studies have been conducted to assess adaptation mechanisms used by African communities (Brooks, 2006; Nyong et al., 2007; Thomas et al., 2007, Mertz et al., 2009). Thomas et al. (2007) conducted a study within three South African provinces, and this study found that the communities’ perceptions of climate change and its impacts resulted in the people undertaking long-term adaptation
strategies. Similar studies are found in other African countries (Mertz et al. 2009; Moyo et al. 2012). However, being aware of climate change and variability, and associated impacts does not always result in farmers adjusting their farming activities. An example of such is farmers in Ghana, where the majority of farmers were aware of climate change however, less than half of them adjusted their farming practices due to temperature increases and precipitation decreases (Fosu-Mensah et al., 2010). If farmers do not adapt, they would become more vulnerable to climate change and variability, thus increasing livestock mortality or crop failure (Jiri et al., 2015).

The willingness of climate change and variability adaptation highly depends on experience, risk tolerance and time (Burton, 1997). Farmers mostly respond to recent climate events, as opposed to trends in long-term climatic changes (Smit et al., 1997; Thomas et al., 2007). Thus making farmers adapt to short-term climate variability than long-term climate change. Burton (1997) argues that coping with short-term climate change variability might result in long-term climate change adaptation. However, others (Smithers and Smit, 1997; Ziervogel et al., 2008; Dilling et al., 2015) argue that short-term coping strategies could increase vulnerability to long-term changes, where a response to one stress can expose or intensify the system to other risks (Belliveau et al., 2006) and could result in maladaptations (McCarthy et al., 2001; Orlove, 2005).

There is a need for studies that focus on understanding farmers’ adaptation strategies that can be successful for agricultural land use systems (Amadou et al., 2015). However, adaptation is area-based and thus the adaptation strategies implemented need to be specific to that particular area (Nhemachena and Hassan, 2008; Kurukulasuriya and Mendelsohn, 2008; Lobell et al., 2008; Seo et al., 2008). This current study, therefore, aimed to assess how livestock farmers in the Leliefontein village and Steinkopf adapt to the climatic and environmental changes they experience. The aim of this study is to also report and interpret barriers to both livestock farming and climate made change and variability adaptation to livestock farmers.
This chapter attempts to answer the following questions:

1. What are the adaptation strategies used by Leliefontein village and Steinkopf livestock farmers in the Namaqualand region?
2. What factors act as barriers to climate change and variability adaptation in Leliefontein village and Steinkopf in the Namaqualand region?

5.2 Methods and materials

Data collection involved two main methodologies which include focus group discussions and in-depth semi-structured interviews (as discussed in chapter 3). During focus group discussions and semi-structured interviews, pastoralists were asked about the adaptation strategies they use to counter-act the observed climatic and environmental changes and the potential impacts of climate change and variability. During focus group discussions, farmers were also asked to list and rank barriers they are currently facing that hinder their adaptation to observed climatic changes. One-on-one in-depth semi-structured interviews were conducted following the focus group discussion. Due to the interviews being semi-structured, in some instances, follow-up questions were asked.

5.3 Results

5.3.1 Temporal climate change adaptations in Namaqualand

In both study sites, farmers reported that they are taking actions that adapt towards the perceived climate change and variability. These can be grouped into daily, seasonal, drought (extreme events) and long-term adaptation strategies (Table 5.1).

Examples of daily strategies used by farmers in the study areas include rotating of grazing routes, and animals feeding on pods in the rangeland. Farmers in Leliefontein village and Steinkopf do not follow the same grazing route they have
followed the previous day. Different grazing routes are followed each day; however, the grazing route has to have the basic resources of (i) closeness to water, (ii) availability of palatable plants and (iii) the limited abundance of poisonous plants and (iv) no other herds in the grazing area. The changing of grazing routes is to prevent overgrazing and expose their livestock to a different diet, because plant species differ along different grazing routes.

Another daily response involves the farmers collecting plant material (pods, twigs, or grasses) that are not easily accessible to livestock and feeding the livestock these plant materials at home. This strategy of “cut and carry” in Leliefontein village is largely to assist lambs that are still weak and cannot spend the whole day walking. However, cut and carry is also sometimes applied to adults during limited forage or drought years and thus can be seen as a supplementary feed strategy.

Seasonal strategies include providing livestock with supplementary feed, changes in lambing season and transhumance. Changing the lambing season involved allowing the rams to mate depending on changes in the rainfall season. For Steinkopf farmers this change in lambing season involved allowing breeding in both the winter and summer rainfall areas. This change in lambing strategy is to reduce livestock mortalities and have two breeding seasons to recover the herd size in cases where mortalities occurred during a drought and for the livestock to utilize the available forage after rains.

One female farmer in Leliefontein village indicated that she has changed her lambing season according to the rainfall variability, by using climatic and environmental indicators as to when rainfall can be expected.

For both study areas, transhumance is practiced as a strategy to escape forage or water shortages. Due to the location of the Leliefontein village in the mountains, 90% of the farmers indicated that they move to low-lying villages, namely; Tweeriver or Kameelkraans in order to avoid extreme coldness during the winter season. These farmers also noted that it is important for a farmer to give their livestock medication (Pasteurella) to strengthen their immune system for the new
environment they will be moving to. This medication is also normally given to the animals when they move back to the uplands. On the other hand, 85% of Steinkopf farmers indicated that they move between the winter rainfall shrubland and summer rainfall grasslands (Klein Bushmanland and Groot Bushmanland) (Figure 5.1). Some (10%) Steinkopf farmers move to the transition area between the winter and summer rainfall regions. From these results, it is clear that Leliefontein farmers practice vertical transhumance, while Steinkopf practices horizontal transhumance.

Figure 5.1: Steinkopf Communal Area map showing different vegetation types that livestock farmers migrate to escape forage and water reductions. The area inside the broken represents is where most of the farmers move to in summer.

Mobility also included moving livestock to key resource areas during droughts or prolonged dry periods. These areas generally contain better forage quality than the surrounding areas in the rangeland environment. Moving livestock to the Orange River that serves as key resource areas in order to find high quality fodder and water during a drought is a strategy practiced by Steinkopf farmers. Farmers also harvest pods from *Prosopis* trees located on the river banks to provide nutritious food for the livestock and these pods is perceived to aid in milk production for the
lambs. Unfortunately, these *Prosopis* trees are being cut down by the Working for Water Programme as the trees are believed to use excessive water, thus limiting forage availability. In Leliefontein, small pockets of ephemeral wetlands act as key resource areas for forage and water during the drought periods.

A small portion of the interviewed Leliefontein village (10%) and Steinkopf (5%) farmers indicated that do not practice seasonal movement, because they believe that there is food available for their livestock from their cultivated lands when they feed the livestock stubble. Another reason for not moving, especially in Steinkopf, was the lack of finances to pay for the transportation of their livestock since they have to move more than 20 km to Bushmanland. However, from field observations, it was seen that these farmers that do not practice seasonal movement are farmers with fewer livestock numbers.

Reducing livestock during droughts or due to limited forage during the dry summer season, either through sale or slaughter is strategy practiced by Leliefontein and Steinkopf farmers. In both current study areas, livestock is slaughtered for consumption and sold informally to speculators in order to avoid high mortalities in a herd. Livestock sold are usually lambs in good condition, or the farmers identify weak adult animals in their herds and sell them. The selling of these livestock is to gain income in order to buy supplementary feed for the remaining livestock. Steinkopf farmers also sell their livestock to get income that they use to buy medication for livestock.

Long-term strategies include acquiring knowledge and having mixed herds of browsers and grazers. To reduce the impact of grazing on their rangeland and reduce competition of food, farmers mix their herds with goats that are generally browsers and sheep that are grazers. Due to the farmers reporting the less reliability of local knowledge for climate change indicators and the impacts of it to the environment and their livestock, they have applied a strategy of seeking additional knowledge through workshops organized by NGOs, accessing the knowledge through media communication or engaging amongst themselves and other farmers.
Table 5.1: Focus group discussion and in-depth interview results on local adaptation strategies between Leliefontein village and Steinkopf livestock farmers.

<table>
<thead>
<tr>
<th>adaptation</th>
<th>timeframe</th>
<th>Steinkopf (%)</th>
<th>Leliefontein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sell off animals that are still in good conditions</td>
<td>drought</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>use income from other sources e.g. salaries</td>
<td>drought</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>save money to buy animal feed</td>
<td>long term</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>slaughter animals for household consumption</td>
<td>drought</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>animals graze close to home</td>
<td>drought</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>feeding them with crop residues</td>
<td>seasonal</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>sell animals to buy vaccines</td>
<td>drought</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>sell off animals to buy feed</td>
<td>drought</td>
<td>10</td>
<td>45</td>
</tr>
<tr>
<td>change herd composition</td>
<td>long term</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>plough their lands</td>
<td>seasonal</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>migrate to areas that received rain</td>
<td>seasonal</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>transhumance between shrubland and grassland</td>
<td>seasonal</td>
<td>85</td>
<td>0</td>
</tr>
<tr>
<td>move to ecotones between seasons</td>
<td>seasonal</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>vertical transhumance</td>
<td>seasonal</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>move to rest veld</td>
<td>seasonal</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>two lambing seasons in different rainfall areas</td>
<td>seasonal</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>change lambing seasons based on rainfall periods</td>
<td>seasonal</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>build shelters for animals for cold nights</td>
<td>seasonal</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>transporting water to animals</td>
<td>seasonal</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>herding to access suitable areas</td>
<td>seasonal</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

http://etd.uwc.ac.za/
merging herds to share labour and input costs & drought & 10 & 0  
herd splitting & seasonal & 5 & 0  
mixed herds of browsers and grazers & long-term & 40 & 25  
keep herd size small & drought & 25 & 20  
access key resource areas & drought & 5 & 0  
access wetlands & seasonal & 0 & 15  
reads signs of animal behaviour & seasonal & 30 & 25  
read signs on veld condition & seasonal & 55 & 75  
read signs in weather & seasonal & 50 & 80  
informal knowledge exchange between farmers & long-term & 55 & 45  
use media for additional information & long-term & 15 & 0  
attending workshops for information & long-term & 25 & 35  
alternate grazing routes daily & daily & 25 & 25  
Pasteurella vaccination for cold temperatures & seasonal & 0 & 5  
dose vitamin A during prolonged summers & seasonal & 0 & 5  
dip livestock for ticks & seasonal & 20 & 5  

http://etd.uwc.ac.za/
5.3.2 Barriers to successful livestock farming and climate change adaptation

When farmers during focus group discussions were asked what are current challenges they are facing that prevent them from farming and adapting to climate change and variability, a comprehensive list was agreed upon by them (Table 5.2). While farmers referred to a number of challenges, the most important challenges similar to both study areas were (1) poor infrastructure maintenance, (2) lack of support from the government, (3) no access to formal markets, and (4) not enough land. The lack of drought relief was also listed as an important challenge by Steinkopf farmers, while overgrazed areas were listed by both study sites, and the lack of crop farming implements was also listed by Leliefontein village farmers.

Farmers in these two areas also made it clear that the lack of support from the local and national government makes their farming practice a ‘struggle existence’ and hinders them from carrying out certain adaptation strategies. The lack of sufficient land and the maintenance of infrastructure were two factors mentioned by the farmers that are currently making their adaptation an ever more challenging experience.
Table 5.2: Major challenges farmers identified in Steinkopf & Leliefontein focus groups.

<table>
<thead>
<tr>
<th></th>
<th>Steinkopf</th>
<th>Leliefontein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought relief¹</td>
<td>Poor infrastructure and roads¹</td>
<td></td>
</tr>
<tr>
<td>Infrastructure (water points &amp; fences)²</td>
<td>Incompetent/ lack of support from local government²</td>
<td></td>
</tr>
<tr>
<td>Lack of support from government &amp; Local government in particular³</td>
<td>Not enough land⁴</td>
<td></td>
</tr>
<tr>
<td>No access to formal markets (only speculators)⁴</td>
<td>Overgrazed areas⁴</td>
<td></td>
</tr>
<tr>
<td>Empty promises from different organisations³</td>
<td>Youth lack of interest in farming⁵</td>
<td></td>
</tr>
<tr>
<td>Not enough land⁵</td>
<td>Do not have the necessary inputs such as seeds or tractors to do cropping. Also, do not have fences to camp these croplands⁵</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Least concern challenges</strong></td>
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<tr>
<td>Poisonous plants that cause Krimpsiekte (disease)</td>
<td>Extreme cold/ snow- Cold is most severe than drought, as this is where most of the lambs die (livestock die as result of coldness/hyperthermia).</td>
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<tr>
<td>Feral donkeys and horses /‘Ongediertes’</td>
<td>Lack of formal markets to sell livestock decent prices</td>
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<td>Ticks (‘bosluise’)</td>
<td>General lack of respect among farmers</td>
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<td>Vandalism of infrastructure</td>
<td>Dogs in the village bite sheep and goats.</td>
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<td>Unemployed youth</td>
<td>Type of livestock breed not adapted for the harsh conditions of the area</td>
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*Superscript numbers are the ranking scores from most concern (1) to least concern (5)
Other factors that inhibited the farmers from successfully adapting to climate change and variability included the poor current environment condition, rainfall variability, and overgrazing that usually results in the decrease of nutritious plants and increase in unpalatable or poisonous plants. *Tylecodon wallichii* and *Galenia africana* were the two plants that were reported by farmers to have increased in the areas and if consumed by livestock, they result in certain diseases.

An equally important aspect that resurfaced throughout the Leliefontein village and a few of Steinkopf interviews was that the farmers are reaching old age, and thus they cannot continue farming in the near future. In fact, the age of about 89% of interviewed farmers in the Leliefontein village ranges between 50 and 78 years. Farmers raised concerns of health problems that prevent them from performing certain agricultural practices. For examples, farmers mentioned that they can no longer walk long distances in the rangeland with their herds, or can no longer walk the seasonal movement routes due to knee problems. In these cases, they have to rely on herders which are usually the youth. However, the farmers themselves raised the opinion that the youth is not interested in livestock farming, thus leaving the old farmers with few options to adapt due to their health problems.

The youth were in general referred to as being ill disciplined, vandalizing infrastructure, into alcohol and drug abuse and just plain lazy. The following quote by one of the interviews, highlight these concerns expressed,

“I think we are the last generation that will partake in farming. They (youth) have no interest and if we die today they will sell the animals the next day. The youth do not know what suffering is... Our kids are problematic. Just last night a young teenager committed suicide. And on Monday, a girl was knocked over after she crossed the national road in the drunken state. Our kids are not disciplined, so I do not know whether this democracy is helping our cause...”

-Steinkopf farmer
5.4 Discussion

5.4.1 Current adaptation strategies practiced by Namaqualand livestock farmers

(a) Supplementary feed

To ensure that livestock mortalities are lowered and livestock weight does not decrease drastically during the prolonged dry season and droughts, farmers from both study areas use different kinds of supplementary feed. According to Morton (2006), the practice of providing tree pods or leaves to livestock as supplementary feed is common in East African communities, as practiced by livestock farmers from this current study. Farmers who have access to arable land plant crops that include lucerne, oats, rye and barley. The establishment of cultivated pastures as practiced by livestock farmers reduce the community’s vulnerability to climatic and environmental change (Batima et al., 2006). However, some farmers in Steinkopf have stopped ploughing due to rainfall unpredictability and water scarcity in the area. In Leliefontein, feral donkeys which damage growing crops resulted in some croppers abandoning their practice (Samuels, 2013).

For other farmers in Leliefontein village and Steinkopf, buying the supplementary feed with money they obtained from selling livestock, government pension or salaries are other actions they take. Similar findings of selling livestock as an adaptive strategy to climatic shocks have also been reported for Ethiopian (Deressa et al. 2009) and Kenyan farmers (Silvestri et al., 2012; Bishaw et al., 2013). The strategy of buying supplementary feed for livestock is practised by farmers to reduce the vulnerability of livestock to summer drought (Ayantunde et al., 2000; Morton; 2006; Howden et al., 2007; Fahim et al., 2013; Ogunkoya, 2014) and winter dzud (heavy snow cover with extreme cold temperatures) (Batima et al., 2006). Livestock trading for the purchase of supplementary feed is another common strategy practiced by African communities (Fahim et al., 2013) but not reported in this study.
(b) Changing of breeding season

Majority farmers interviewed practiced controlled seasonal breeding. Some change their lambing season according to rainfall to ensure a decrease in lamb mortality, as forage would be abundant in the area for both the lamb and the mother for milk production. A study conducted by CSIRO in Australia found that about 40% of Victorian farmers are shifting their lambing and calving to be earlier due to the changing seasons (Scienceinpublic, 2012). Changing lambing or calving season as an adaptation strategy to climate change is also suggested to Scotland farmers (SRUC, 2016).

(c) Transhumance

Steinkopf farmers reported moving between the summer rainfall area (Klein Bushmanland and Groot Bushmanland) dominated by grasses and the winter rainfall area dominated by shrubs. Since Leliefontein is located in the mountains of the Kamiesberg, farmers in the area move up and down the mountain to escape extreme cold conditions during the winter season. The 10% of Steinkopf livestock farmers that migrate to the ecotone between the grasslands and shrublands mentioned that the ecotone are the safest area to be in as it provides easy access to move to either side of the rangeland.

Transhumance is one example of local adaptation strategies that are based on perception and experience. This movement of livestock between grazing lands to exploit the seasonal availability of fodder and water is part of ethnic identity across global indigenous communities (Blench 2001; De Bruijn and Van Dijk 2001), including the Namaqualand region in South Africa (Hendricks et al., 2002; Baker and Hoffman 2008; Samuels, 2013).

The seasonal movement of livestock allows maximum forage intake across a variety of climate regimes (Danckwerts and Tainton, 1996; Ali, 2008; Teshager, 2014). In South Africa, it was used effectively by the Khoikhoi for over 2000 years (Smith, 1983; Hoffman et al, 1999). It still currently persists, as the current
study results show that livestock farmers in Namaqualand who are descendants of the Khoikhoi still practice it, even though constrained by land ownership, conservation and social factors (Samuels, 2013). This practice and the transhumance routes followed indicate a rich understanding of resource availability and which areas should be avoided during times of resource scarcity (Penn, 1986). Thus continuous access to other areas is important for this type of farming as it enables movement between different ecosystems in response to local climatic problems (Nakashima et al., 2012), and is crucial to the maintenance of culture and livelihood (Ayantunde et al., 2011).

The IPCC states that:

“Mobility remains the most important pastoralist adaptation to spatial and temporal variations in rainfall, and in drought years many communities make use of fall-back grazing areas unused in ‘normal’ dry seasons because of distance, land tenure constraints, animal disease problems or conflict. But encroachment on and individuation of communal grazing lands, and the desire to settle to access human services and food aid have severely limited pastoral mobility.” (IPCC, 2007: 293)

Transhumance seems to be the main climate change and variability adaptation strategy practiced by farmers in semi-arid and arid regions (Wouterse and Taylor; Schlenker and Lobell, 2010). This strategy is important for these semi-arid regions as it serves as a response to temporal environmental and climatic changes (Fernández-Giménez and LeFebre, 2006; Katanha and Chigunwe, 2014; Berkes and Jolly 2001; Agrawal 2010; Fernández-Giménez and Estaque, 2012).

Sedentarization, which refers to the permanent homestead settlement of nomadic or semi-nomadic people (Salzman, 1980) has also taken place amongst some of the farmers in this study and has increased in African countries due to economic, political, droughts and environmental changes (Fraktin et al., 2006). Reasons for not practicing seasonal movement by the interviewed farmers for the current study included the belief of sufficient livestock food availability from their croplands or
stubble and lack of finances to transport their livestock. Pastoralists in northern Kenya prefer not to move so they can be closer to health and socio-economic services (Fraktin et al., 1999) whereas Fulani herders in Senegal do not move as it is labour intensive (Adriansen, 2008). There are however negative environmental impacts of sedentary pastoralism (Salzman 1980; Schwartz 2005). Sedentary pastoralism can result in depletion of natural resources, land degradation and increase the environment’s vulnerability to natural disasters (Schwartz 2005).

(d) Mixed herds of sheep and goats

Farmers who keep mixed herds in Leliefontein and Steinkopf usually have a mixture of goats and sheep in one herd. The goats generally prefer to browse on shrubs, while the sheep prefer to graze on annual plants and grasses but, this feeding behaviour could change during the seasons and when different herd management strategies are used (Samuels et al., 2016). The mixing of grazers and browsers in a herd by pastoralists does not only decrease plant resource competition between the animals, but it also forms part of risk management adaptation strategy (Orindi et al., 2007). This is because the different groups in a herd will not be affected similarly during extreme events, e.g. drought. This ensures that even after a drought, farmers will continue with the farming practice. The mixture of different livestock species is regarded as an effective diversification strategy and is more commonly adopted by pastoralists to make better use of pastures with herbaceous and woody plants (Liao, 2015).

In addition to mixed herds, one farmer in Steinkopf raises the need for drought tolerant sheep since their current Dorper cannot withstand droughts. This need was elicited by the sheep mortalities that occurred during the recent 2014/15 drought. One of the youngest farmers in Steinkopf who lost over 60 individuals of his Dorper sheep but all of his 100 Boerbok survived the drought period. This young farmer together with other farmers who mostly lost their Dorper sheep attributed their loss to rainfall. After a prolonged dry period, Steinkopf experienced high amounts of rainfall that fell over a short duration, which brought
along them intense cold temperatures. The animals thus could not survive the cold as they were weak from the previous drought.

Another factor that can be attributed to the loss of Dorper sheep and not goats during the 2014/15 drought can be the different feeding behaviours of the animals. Goats tend to cope better than sheep during dry periods with limited annual plant growth (Mundy and Masallam, 2000). Moreover, the fact that Boer goats are more adapted to hot rather than cold environments (Tilahun, 2012), places emphasis on its ability to convert poor-quality forage into meat at a very low cost, thus enabling it to survive severe droughts. Thus Leliefontein village experienced higher mortalities of goats during the recent 2014/2015 drought, since Leliefontein village is located in the mountains and thus is colder than Steinkopf. This also emphasizes the argument raised by Steinkopf farmers that a small portion of their goat mortalities were mostly due to cold temperatures rather reduced forage, and a large amount of their livestock mortalities were in sheep due to reduced forage caused by the 2014/2015 drought.

(e) Acquiring additional knowledge

Livestock farmers of Leliefontein village and Steinkopf have been acquiring additional information on climate change and potential adaptation strategies that have been a success in other similar areas (Chapter Four). Improved communication measures on information that is related to climate change and variability can be viewed as an option to assist farmers with decision-making and possible adaptation (Moyo et al., 2012). The ability of farmers to enhance their information on climate-related issues can increase the number of potential adaptation strategies they can adopt. New information and technologies are often introduced to farmers by research programs that try and explore possible options farmers can undertake to adapt (Below et al., 2010). For example, livestock farmers may initiate different breeds that are drought tolerant (Nassef et al., 2009), as South Asian livestock farmers have changed their livestock breeds over the past ten years due to climate variability (Bhatt and Aggarwal, 2016).
Climate information availability is also of importance for communities to adapt to climate change and variability. Information Communications Technology (ICT) tools such as mobile phones, community radio, and participatory videos serve as a communication media of information and knowledge of climate change and adaptation challenges (Duncombe, 2006; Ospina et al., 2012). These tools enable communities to be informed, educated and influenced in behavioural changes that are needed to reduce climate change vulnerability (Houghton, 2009; Kalas and Finlay, 2009). An example is with Bangladesh farmers in a project conducted by Torres (2009), where these farmers used mobile phones to share and learn from one another. In South Africa, the government has launched a campaign that promotes the country’s National Climate Change Response policy. Tools used in this campaign included television, radio, print media and the internet, with an aim to build awareness on the causes and effects of climate change in order to increase resilience.

5.4.2 Adaptation barriers

(a) Financial barriers

Many farmers in both the current study areas are impoverished and rely on social grants from the government (Samuels, 2013), meaning their income is limited to cover their agricultural inputs and sustain their families. This is a problem to the farmers because implementations of some adaptation strategies require costs (Katanha and Chigunwe, 2014). In most communities of the developing countries, these cost-essential strategies are often not effective due to financial challenges. For example, the purchase of drought tolerant livestock, the purchase of medication for livestock disease, or the purchase of livestock supplementary feed as adaptation strategies often hinders adaptation for poorest communities.
Lack of readily functional markets

Since farmers may reduce their livestock numbers through sale, as an adaptation strategy, this is often through off-markets sales and not through formal markets. This was mentioned as a major challenge by farmers from both areas. This regularly results in the farmers selling the livestock at a lower price to that of the real market value. As money derived from these sales is intended to buy supplementary feed or medication for the remaining livestock; this becomes challenging with the insufficient money farmers receive from the off-market business. Similar results of off-market trades were found by Katanha and Chigunwe (2014) with fruit farmers in Zimbabwe having to sell their fruits in their yards at lower prices due to the decreases in quality from the traditional storage facility that result in the pest and insect infestation. The informal market used by communal farmers includes selling to speculators. However, there is dissatisfaction amongst farmers who sell their livestock or crops to speculators. This is mainly due to the dishonesty of speculators where they employ techniques that may involve manipulation of the farmer’s socio-economic background, illiteracy and little knowledge of formal markets (Nkosi and Kirsten, 1993). These techniques are used to convince the farmer who is need of the money to agree to sell their livestock at often a cheaper price. This often leaves the farmer unhappy because the price was not negotiated fairly, and therefore not a true reflection of the real market price.

Vandalism of infrastructure the unemployed youth

An important aspect that resurfaced throughout the interviews was that the future of pastoralism relies heavily on the involvement of the youth in farming. Farmers in the areas under study lamented the lack of involvement of the youth in agriculture. The youth were in general referred to as being ill disciplined, vandalizing infrastructure, alcohol and drug abuse and just plain lazy. In general unemployment levels are high in semi-arid areas in southern Africa. In the post-apartheid South Africa, unemployment among youth is increasing and the
unemployed youth are frequently considered to be vulnerable to crime, drug and alcohol abuse (NYDA, 2011). Thus they vandalize or steal the pieces of the infrastructure that are needed by livestock farmers, in order to have cash to sustain their drug habits.

(b) Poor environment condition with an increase in unpalatable and poisonous plants

One of the main reasons provided by the farmers was poor environment conditions that are expected to further decrease, due to various factors. These factors include rainfall variability, overgrazing and the increase of unpalatable and poisonous plants. The fact that several farmers in Steinkopf are production orientated plays a major role with the livestock numbers and breeds they keep, and their impact on the environment. The slow divergence from subsistence to more commercially orientated production has resulted in some farmers in Steinkopf growing their herds to large amounts, thus causing degradation.

*Tylecodon wallichii* (Krimpsiekbos as locally known) was identified as the most poisonous plant that occurs in both areas under study. This plant causes krimpsiekte, translated from Afrikaans means “shrinking disease”. This shrinkage is a sign for chronic cardiac glycoside poisoning (Kellerman *et al.* 2005). This disease was one of the first diseases documented in 1891 to be toxic for South African small stock (Curson 1926); and is mostly evident in the Little and Great Karoo (Kellerman, *et al.*, 1996). The absence of a specific treatment for this disease raises concerns of how will farmers respond to it, as there is an increase in the number of the poisonous plant causing the disease.

(c) Decrease in knowledge transfer

The literature on pastoralism in Africa has highlighted the importance of the use of local knowledge in climate change adaptation (Roncoli *et al.*, 2002; Boko *et al.*, 2007; Orlove *et al.*, 2010; Newsham, 2011). Examples include the Sahel,
where this knowledge is not only used for weather forecasting but, also used for emergency fodder during droughts, mixed herd composition to survive extreme climatic events, and transhumance (Nyong et al., 2007). However, for the current study, this knowledge was reported by farmers from both study areas to have been eroding due to the lack of interest in livestock farming by the youth.

The eroding of this knowledge was due to the lack of or decrease in its transfer from the older to the younger generation. For instance, the lack of transfer of the knowledge of (1) what indicators to look for that anticipate change, (2) where, when and how to move within the rangelands or between seasonal grazing areas can often result in large amounts of livestock mortalities of either young or emerging farmers, thus decreasing their adaptive capacity.

The eroding modes of knowledge transfer and isolation of the young generation from the older generation are examples of factors contributing to the decrease of indigenous communities’ resilience (Ford et al., 2006). Berkes (2009) further emphasizes this by stating that if this knowledge transfer continues to degrade, then younger generations in future will have difficulties in understanding their observations, because it is elders that must help the younger generation construct this knowledge.

***(d) Lack of government support***

The lack of sufficient land, drought relief and the maintenance of infrastructure were mentioned by Leliefontein village and Steinkopf farmers to be the biggest issues which involved local and national government. The aspect of alternatives or the inability to diversify land use due to lack of land or lack of access to land makes it ever more difficult to adapt to climatic or environmental changes for these communal farmers. Muller and Shackleton (2013) stressed that climate change in itself does not appear as the most pressing issue among commonage farmers in the Karoo as their current situation is ever dilapidating as a result of poor local government.
The lack of infrastructure maintenance, especially roads and windpumps was listed as the main threat to the continual utilization of certain areas in their rangelands and seasonal movement. The lack of community infrastructure maintenance was reported by Antwi-Agyei et al. (2013) as a barrier to climate change and variability adaptation.

Higher stress on windpumps maintenance was placed by Steinkopf farmers, while Leliefontein village farmers stressed over road maintenance. There are few functional water points in Steinkopf, resulting in many farmers congesting it during prolonged dry periods or droughts. As Leliefontein is situated in the mountains, it receives high amounts of rainfall and has a high number of water sources such as wetlands and springs distributed in the area. This could explain why farmers in the area view windpumps maintenance as a moderate threat to Leliefontein farmers. However, this is only applicable to Leliefontein village farmers and not the other surrounding villages in the Leliefontein Communal Area. Thus general conclusions cannot be drawn for the entire commonage, but only for one specific village.

Farmers normally migrate with their animals by using roads. Farmers, especially in Leliefontein stressed that their gravel roads are not being maintained and as a result have trouble moving their herds due to erosion that occurs on the roads. Steinkopf farmers did not place high stress on road maintenance perhaps because they live closer to the national road (N7), and thus often if they possess a vehicle, and use one to migrate.

5.5 Conclusion

This current study showed that livestock farmers in the Leliefontein and Steinkopf have adopted traditional (which have been tried and tested) and new adaptation strategies to the perceived and actual changes occurring in their climate and rangelands. These adaptation strategies can be daily, seasonal, drought or long-term strategies that are targeted at both climate change and variability. Amongst other strategies, farmers still continue to practice transhumance, they provide
supplementary forage to their livestock, alter lambing season, and enhance their knowledge on climate change and variability, impacts, and possible adaptation strategies.

Even though the strategies adopted by the pastoralists are traditional, they are still viewed by the pastoralists as a valid response to climate and environmental changes. However, they may become less effective in the future climate; as a result, farmers are seeking additional information that might be effective in current and future adaptation.

This study also reveals that even though adaptation measures are being carried out in the two study sites, however, there are general barriers that inhibit effective adaptation. These include financial, biophysical environment, social and institutional barriers. It would appear therefore that the main threat for the future of pastoralism and adaptation in Steinkopf is environmental. However, these environmental challenges are linked to social, economic and political aspects, in terms youth involvement, market demand, and political support. It can be concluded that farmers from both Leliefontein and Steinkopf believe that their respective areas will have fewer pastoralists and livestock in the near future.
CHAPTER SIX: STUDY SYNTHESIS AND RECOMMENDATIONS

6.1 Introduction

The rapid rate at which climate is changing is largely affecting people who are dependent on natural resources. This fast rate results in challenges that push the people to their thresholds, therefore testing their adaptability and resilience (Marshall and Stokes, 2014). The survival and continuation of these communities is dependent on their adaptation strategies (Katanha & Chigunwe, 2014).

Adaptation strategies aid African farmers to cope with climate change and variability. Even though a large amount of studies (Thomas et al., 2007; Hassan and Nhemachena 2008; Mertz et al., 2009; Nyanga et al. 2011; Ajani et al., 2013) have shown how different communities have adapted to climate change and its impacts; a few have been conducted in pastoral areas in South Africa. Pastoral communities in South Africa are generally found arid and semi-arid areas. Farming in these areas is risky as variations in rainfall and the environment determine the productivity (Rao et al., 2011), however, farmers continue to farm to sustain their livelihoods. Communities in drylands, including those in the current study areas, are the ones that need most adaptation, as their livelihoods are already challenged by low agricultural productivity due to their limited and unproductive land.

With the inter-liked challenges that farmers in arid and semi-arid regions of South Africa face, they have to make survival decisions in order to adapt to the seasonal variability and uncertainty. Thus, the aim of this study was to assess climate change related ecological knowledge and adaptation in semi-arid regions of South Africa, by using Leliefontein Communal Area and Steinkopf Communal Area as case studies.
6.2 Local ecological knowledge implanted in interactions with nature influence community resilience

**Figure 6.1:** Linkages of local knowledge, perceptions, and experience, and how these influence community vulnerability through adaptation.

Adaptation strategies utilized by smallholder farmers are dependent on their knowledge and other various sources of that information (Bello *et al.*, 2013). In most cases, this knowledge is shaped by experience which further influences a person’s perception on a particular topic (Figure 6.1) (Ajibade. 2007; Salick and Byg 2007; Teshager, 2014). This was also evident in the current study, where both Leliefontein village and Steinkopf livestock farmers’ knowledge on climate change and variability was derived and shaped by their experiences, amongst other various sources of information. Due to the nature of acquiring local knowledge through interactions with the environment, it can be said that local ecological knowledge is rooted in the people’s experiences, observations (Ghorbani *et al.*, 2013; Fernández-Giménez and Estaque, 2012), needs (Davis and
This knowledge has been accumulated for centuries and is used by communities to develop adaptation strategies (Wiid and Ziervogel, 2012). Besides the knowledge transferred to the livestock farmers by their forefathers in the current study; interactions with their rangelands proved to be the root of their ecological knowledge that shaped and influenced their perceptions and adaptation strategies. Various authors (Roncoli et al. 2002; Hansen et al. 2004; Vogel and O’Brien 2006; Thomas et al. 2007) agree that climate change and variability perceptions are necessary requirements for adaptation.

6.3 What do Namaqualand livestock farmers know, experience and perceive about climate change?

6.3.1 Climate change awareness

This study found that in both study areas farmers were familiar with the phenomenon of climate change however; the term was new to their vocabulary. Steinkopf and Leliefontein village livestock farmers indicated that they understand and could explain climate change. A local reference term to climate change that farmers mostly in Leliefontein village prefer to use was found to be seasonal shifts. The use of this term by farmers is due to the shifts in the start and cessation of seasons that farmers have been experiencing. When the farmers’ explanation of seasonal shifts was compared to the globally accepted definition of climate change according to IPCC (2014), it was found that similar descriptions exist. Both seasonal shifts and climate change descriptions focus on variations in precipitation, temperature, and wind.

The major source of information in both areas under study was listed as inter-generation knowledge transfer between the current farmers and their forefathers. Media sources such as television and radio, and attendance of regular farmers’ meetings was also mentioned by the farmers as alternative sources of information.
The results found in this current study of livestock farmers being aware of climate change and variability (and associated environmental changes), deviates from results found in the other South African studies (Muller and Shackleton 2013; Mudombi, 2014). However, there are examples (Mandleni, 2011; Lebel et al. 2015) of studies that found similar results to the current study of farmers being aware of climate change and its impacts. Farmers, who were aware of climate change, indicated that a large portion of their knowledge generates from local knowledge derived inter-generational knowledge transfer and media sources. Similar results have been reported by various literature (Kandlinkar and Risbey, 2000; Weber 2010; Adam et al., 2015; Mudombi, 2015).

### 6.3.2 Observed climatic and associated environmental changes

Most of the interviewed farmers highlighted that they rely more on environmental, plant and animal behaviour indicators when making critical agricultural decisions. However, due to erratic climatic changes, their reliance on local knowledge for climate predictions is now decreasing, thus farmers are now seeking and combining their knowledge with scientific weather forecasts.

A wealth of information on observed climatic and environmental changes was given by the respondents with long farming experiences. The majority of Leliefontein village farmers have over 18 years farming experience thus could provide narrative climatic and environmental changes they have observed over decades. On the other hand, the majority of Steinkopf farmers have less than 18 years’ experience.

**Rainfall:** Farmers from both study areas perceived a delay in onset rains which are an indication of changing climate and environment conditions. Short rainfall duration with increased intensity and decreased time span, was also mentioned as another climatic change noticed by farmers; and this was associated with a decrease on available forage in their rangelands. Results from both interviews and focus group agree that rainfall variability and unpredictability have increased and the pattern of rainfall has been disturbed. When all the farmers’ perceptions were
compared with measured rainfall data for a 100-year period, it was found that these sets of information were similar, except for decreases in total rainfall amounts in Leliefontein village.

**Temperature and wind:** Farmers perceived in an increase in temperature during summer months, and a decrease in temperature during winter months. The high altitude area of Leliefontein village has experienced increases in wind frequency and intensity, while the low-lying area of Steinkopf has experienced weakened winds with a decrease in frequency.

The increased wind intensity and frequency mentioned by Leliefontein farmers’ often blows rain clouds away, thus resulting in low annual plants abundance, which provides forage for the livestock during the wet season. Vegetation change was also mentioned by farmers from both areas as affecting their farming practices. Vegetation changes were mentioned by Steinkopf farmers as a combination of aridity and overgrazing. This change often results in the dominance of unpalatable plants.

### 6.3.3 Perceived impacts of climate change and variability

Extreme cold temperatures during the winter season were mentioned to result in livestock diseases such as pneumonia and livestock mortalities. Increases in temperature during the dry season were mentioned to result in increased occurrences of parasite diseases (ticks). Leliefontein village farmers also reported an occurrence of unfamiliar diseases and symptoms in the area.

Water and forage decreases due to changes in rainfall were mentioned by Steinkopf farmers to result in poor health condition of livestock. The shift of onset rains affects the lambing season, where ewes cannot produce enough milk for their lambs, often resulting in low lamb production. The increased variation and
unpredictability of rainfall in both areas also affects the farmers’ transhumance where farmers sometimes move too late with some of their livestock dying.

This study has shown that Namaqualand livestock farmers have detailed knowledge of climate change and variability (and associated environmental changes), with associated impacts that subsequently affects their livestock farming system. This includes taking into consideration the correspondence of local climate trends and climate change projections, or daily climate forecasting (Howden et al., 2007).

6.4 How do Namaqualand livestock farmers adapt to climate and associated environmental change?

6.4.1 Adaptation strategies
This study showed that livestock farmers in the Leliefontein village and Steinkopf have retained traditional adaptation strategies and adopted a few new ones to adapt to the perceived and actual changes occurring in their climate and rangelands. The adaptation strategies used by these livestock farmers can be grouped into daily, seasonal, extreme events (droughts) and long-term adaptation strategies targeted both at climate variability and change. Examples of daily adaptation strategies include the use of farmers or herders’ local knowledge in order to know which grazing route animals to follow for that particular day, taking the livestock to feed in areas with available forage and water. Seasonal strategies include transhumance, purchasing or ploughing supplementary forage to livestock, and accessing key resource areas (Orange River for Steinkopf and wetlands for Leliefontein village). Transhumance to low altitude areas during the winter season is practiced by Leliefontein village farmers to escape cold temperatures. On the other hand, transhumance between the shrubland (Steinkopf) and grassland (Bushmanland) is practiced by Steinkopf farmers to exploit water and grazing land during summer and winter months. Some farmers in both Leliefontein and Steinkopf indicated that they no longer practice transhumance; as
a result, they plough their lands as means of supplementary feed. For other farmers without land, supplementary feed is practiced through purchasing the feed with money obtained from selling other livestock, government pension or salaries. Long-term strategies include alteration of lambing season in accordance to rainfall variability, and farmers enhancing their knowledge on climate change, its impacts, and possible adaptation strategies. Some farmers in Steinkopf have initiated collective farming in order to share their knowledge and to help each other financially. In order for livestock to escape extreme cold temperatures during prolonged dry summers of droughts, farmers build shelters and stone walls to protect their livestock. Steinkopf farmers have also built shelters in the veld in order for their livestock to escape extreme hot temperatures.

For livestock farmers in other semi-arid and arid regions, transhumance is the main climate change and variability adaptation strategy (Ayantunde et al., 2000; Morton; 2006; Howden et al., 2007; Wouterse and Taylor; Schlenker and Lobell, 2010; Nakashima et al., 2012; Bishaw et al., 2013; Ogunkoya, 2014). This strategy is practiced by Mongolian farmers to reduce the vulnerability of livestock from the extreme cold temperatures and high levels of snow cover during winter (Batima et al., 2006). Besides mobility, Namaqualand farmers supply supplementary feed to their livestock, by ploughing or purchasing the feed. Selling of livestock to derive income in order to buy supplementary feed or medication for livestock is common in African communities (Bishaw et al., 2013; Fahim et al., 2013).

In order for communities and individuals to adapt, their actions are dependent on their ability to cope with impacts and risks of climate change and variability. This is called adaptive capacity, which reduces vulnerability. Adaptive practices are considered as displays of adaptive capacity, which is, in turn, an indicator of vulnerability and thus resilience. Adaptive capacity indicates social learning through change and ability to experiment new practices (Armitage and Plummer 2010, Reed et al. 2010). This is possible with knowledge gathered through experience. Hence local ecological knowledge is considered the key component of adaptive capacity (Berkes et al., 2000), as this knowledge provides information
about observations and understanding of climate or weather changes (Boillat and Berkes, 2013).

Amongst other factors, the ability to adapt to climate change and variability is dependent on information, wealth, policy, technology and skills. Communities and regions that are limited in any way from these factors are known to be more vulnerable to damages of climate change and variability. Thus the improvement of adaptive capacity is a necessity for reducing vulnerability (Smith et al., 2001). This improvement is usually critical for indigenous communities who are generally known to live in remote rural areas with low income, thus are more exposed to social, economic and biophysical environment problems that place them at greater risk to effects of climate change and variability.

6.4.2 Climate change adaptation barriers in Namaqualand

This study reveals that even though adaptation measures are being carried out in the two study sites, however, there are general barriers that inhibit effective adaptation. These include financial, biophysical environment, social and institutional barriers.

The most important challenges similar to both study areas were (1) poor infrastructure maintenance, (2) lack of support from government, (3) no access to formal markets, and (4) not enough land, drought intolerant livestock type with a high market demand, poor environment condition with increasing poisonous plants, youth involvement in agriculture and knowledge transfer.

Climate change will not independently affect the livelihoods of farmers in developing countries (Mandleni, 2011), but there are other factors that are already burdens to people. Examples of these factors include poverty, land use changes, land degradation (IPCC, 2007), local and national government structures, land tenure systems, and finances (Grothmann and Patt, 2005) to name a few. These are institutions that affect the availability and security of natural resources to people (Mandleni, 2011). The lack of the maintenance of waterpumps by local government in both study areas for the current study was listed as one of the
major burdens that affect their farming practice. This results in reduced water availability, especially in Steinkopf, as they do not have natural water sources as alternatives to water access and availability that the Leliefontein village has.

Climate change does not affect the environment alone but, also affects the social, economic and political spheres (Mudombi, 2015). They include access to information via extension services (Maddison, 2006) and credit accessibility (Deressa et al., 2009). Various factors are known to affect the farmers’ capacity to adapt to climate change. Amongst others, they include access and usefulness of relevant information (Roncoli et al., 2002), policies (Eakin and Luers, 2006; Agrawal and Perrin, 2008) and financial position of household and communities (Ziervogel et al., 2006). Lack of information or understanding does not individually inhibit an individual’s and community's ability to adapt, but is affected by a collective influence of information, social, cultural and institutional elements (Tompkins and Adger, 2004). The lack of useful and relevant information from extension services, lack of drought relief, vandalism of infrastructure (crime) for study areas in the current study are some problems that often results in livestock mortalities that further decreases the community’s adaptation capacity.

The data presented in this study shows climate change as only one of the main threats to farming in the Leliefontein village and Steinkopf. Even though there are other factors which are more urgent than climate change, livestock farmers in the two study areas need to nonetheless manage and adapt to climate change and variability. This is because the most urgent factors are interlinked with climate change, and they affect the community’s ability to adapt successfully.

From this study, on the big question that can be asked about communal farmers in Namaqualand is whether the farmers are in a good position to successfully adapt to climate and environmental change, given their suppressing pressures and poverty in the area. This study thus concludes that there is a need for a holistic approach to climate change that links enviro-socio-economic factors of communities, and that tries to deal with the challenges collectively, rather than isolated disciplines. It also concludes that various sectors of society which include
the government, NGOs, media, and schools need to contribute their resources in order for the adaptive capacity of local communities to be increased.

6.5 Recommendations

This research was intended to contribute to the body of knowledge about livestock farmers perceptions on climate change and its impacts and also on the adaptation measures they practice as a consequence of these changes. If the current adaptation barriers expressed by Leliefontein village and Steinkopf farmers are left unresolved, they can increase the vulnerability of both communities; thus reducing their resilience to climate change and its impacts. However, the results of this study may be limited by the sample size. Thus it is proposed that future research could perhaps increase the number of farmers interviewed, or sample more villages within communal areas.

Adaptation requires the participation of various stakeholders including policy-makers, researchers, NGOs, farmers, and communities. This study recommends that in order to draft policies and programs aimed at stimulating successful adaptation to the agricultural sector there is a need for research targeted at understanding farmers’ perceptions of climate change, ongoing adaptation strategies, and barriers to these adaptation strategies. These policies should consider and protect farmers’ local knowledge and it should be considered when programmes aimed at livestock production are decided. It also recommends that there is a high demand for research aimed at assessing the levels of vulnerability of communities, and monitoring the change over time of the impacts and adaptation strategies to climate change.
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Appendix A: Questionnaire used to interview livestock farmers in the study areas

Demographic

1) Name and surname
2) Age
3) Gender
4) Highest qualification
5) Primary source(s) of income
6) Which livestock do you keep?
7) How long have you been farming?

Local understandings of climate change

1) Are you familiar with the term climate change? Can you please explain your understanding about it?
2) Where have you come to learn about climate change?
   a. parents
   b. NGO workshops
   c. media (TV, radio, newspapers, magazines)

Other………………………………………………………………………………………………………………………………………………

3) How does each of the following affect the environment and your livestock? Could you explain these effects?
   a. shifts in seasons
   b. shifts in rainfall

4) Please rank the following according to what you perceive as the main threats of climate change for livestock farming. Please explain why.
   a. high temperatures
   b. low rainfall
   c. droughts
   d. floods
   e. vegetation change to unpalatable plants

Other………………………………………………………………………………………………………………………………………………
Temperature and rainfall

1) Have the seasons shifted over the time you have been farming? How?
2) How many droughts have occurred since you have been farming?
   a. What do you think caused the drought(s)?
3) Has wind direction changed overtime?
   a. If, yes please explain how?
   b. How does this change in direction affect the vegetation, livestock, and you as a farmer?

Landscape changes

1) Could you name and explain (if any) any livestock changes in behaviour or plants that indicate environmental changes? You can also refer to any other animal that indicate environmental change?
2) Which plants are widely eaten during drought, and are healthy for the livestock?
   a. Shrubs
   b. Succulents
   c. Grasses
Other…………………………………………………………………………………………

3) Are there particular plants that are disappearing or increasing in number? If so, which ones?
4) From the list below, what do you think are the causes for such changes? More than 1 answer can be chosen.
   i. habitat degradation
   ii. grazing
   iii. collection for fire
   iv. displacement by invasive
   v. droughts/floods
Other…………………………………………………………………………………………
5) From the answers given in question 3, please rank them from most to least cause of change.

**Adaptation strategies**

1) How do you choose a coping mechanism? Is it things you were taught or saw you parents/grandparents do, or do you make new decisions where you first think about them?

2) How do you prepare for droughts now?
   a. keep herd size at minimum
   b. buy feed
   c. plough / cropping

Other..............................................................................................................................................

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3) Apart from drought what are the other reasons that cause a change in your livestock numbers?
   a. bitten by dogs
   b. bitten by jackal
   c. natural deaths
   d. theft

Other..............................................................................................................................................

4) Do you move during winter and summer months?

5) In which months did you move livestock to the lowlands and back in the past (<20 years ago), and how has that changed?

6) Besides livestock movement and herd composition, is there another method you use to cope with changes in climate?

7) How do you decide on the route the livestock will follow for the day?
   a. Are there specific indicators you look for in the field for good and bad veld? Explain each indicator
      i. green veld
      ii. dense veld
iii. water
iv. type of plants growing there

Other ........................................................................................................................................

8) Do you think livestock farmers in your area will be able to farm in the next 20 years? Why?
9) Do you think you might change to a different land use in the future? Why?
   a. vegetable garden
   b. fruit garden

Other ........................................................................................................................................

Livestock diseases

1) Are there any diseases that are now common to livestock, but were of least concern in the past? What are the causes of these diseases (if known)
   a. krimpsiekte
   b. bloednier
   c. bloutong
   d. heartwater
   e. waterpens

Other ........................................................................................................................................

2) Have tick infestation become more of a problem now than in the past? Please explain

3) In relation to each of the diseases you mentioned in question 1, do you use western or traditional medicine? Why?

4) Did the older people use the same medication in the past?

5) What factors (if any) do you think have led to the breakdown of the traditional use of medicine? Please explain each
   a. loss of interest
   b. no longer effective
   c. modernization
   d. information was not transferred

Other ........................................................................................................................................
Knowledge transfer

1) How do farmers obtain information on adaptation strategies? Who are the key sources of information?
   a. fore-fathers
   b. farmer associations
   c. NGO workshops
   d. media (TV, radio, newspapers, magazines)
   Other

2) How do farmers share knowledge with each other?
   a. oral demonstration
   b. farmers meetings
   c. workshops
   Other

3) How do farmers share knowledge with youth?
   a. oral demonstration
   b. farmers meetings
   c. workshops
   Other