# Building resilience to climate risk in the agricultural sector through adaptation education using a climate-smart approach: The case of the Mooifontein region, North-West province

**JA Mathews**
**24480185**

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Supervisor: Mrs L Kruger
Co-supervisor: Mr GJ Wentink

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# ABSTRACT

Climate change has been identified as a high profile, environmental concern that threatens to cause extensive loss and hardship. There are two distinct responses to climate change, namely mitigation and adaptation. Much attention has been paid to reactive mitigation efforts to reduce greenhouse gas emissions. The international disaster risk management (DRM) community has, however, also identified adaptation as an anticipatory strategy to pre-empt risks associated with hazards arising from climate change and to build resilience in vulnerable communities. It is also significant that symbiotic links between climate change risk and development goals have been identified by policymakers and DRM specialists who recognise that climate change is a risk for all national development initiatives.

In this study adaptation is explored as a strategy to reduce one farming community's vulnerability to climate risk. The aim was to identify adaptation opportunities using appropriate climate-smart farming systems that could build the resilience of farmers in the Mooifontein region of the North West province of South Africa. Since it is a rural, agrarian-based economy, the investigation was focused on the issue of climate change risk to the local agricultural sector.

Disaster risk reduction (DRR) practitioners acknowledge the importance of understanding hazards such as climate change within a socioeconomic framework, in particular where human activity might be exacerbating levels of vulnerability. It is thus essential to employ adaptation processes to increase the resilience of the lives and livelihoods of those most vulnerable to risks associated with climate change. These should be addressed through region-appropriate adaptation as part of national development agendas. Knowledge gaps must be bridged with communication strategies based on multi-sectoral insights and the participation of all stakeholders, including the affected community.

The aim of this study was therefore to identify examples of knowledge transfer and effective channels of communication for future initiatives. This goal is premised on the awareness that any adaptation approach to development and increasing the resilience of communities at risk is dependent on the successful dissemination of information.

Key concepts:

Adaptation; adaptation education; climate change; climate-smart agriculture; conservation agriculture; coping capacity; disaster risk reduction; mitigation; resilience; vulnerability.

# OPSOMMING

Klimaatsverandering is geïdentifiseer as ’n hoë-profiel omgewingsaangeleentheid wat dreig om omvattende verliese en lyding te veroorsaak. Daar is twee besliste reaksies op klimaatsverandering, naamlik versagting en aanpassing. Baie aandag is geskenk aan reaktiewe versagtingspogings ter vermindering van kweekhuisgasvrystellings. Die internasionale ramprisikobestuurgemeenskap het egter aanpassing as ’n pro-aktiewe strategie geïdentifiseer om risiko’s wat verband hou met die gevare voortspruitend uit klimaatsverandering, voor te spring om sodoende veerkragtigheid in kwesbare gemeenskappe te bou. Dit is ook opvallend dat ‘n simbiotiese verband tussen klimaatsveranderingsrisiko en ontwikkelingsdoelwitte geïdentifiseer is deur beleidmakers en ramprisikobestuurspesialiste wat erken dat klimaatsverandering ’n risiko vir alle nasionale ontwikkelingsinisiatiewe is.

In hierdie studie word aanpassing ondersoek as ’n strategie om die kwesbaarheid van een boeregemeenskap se klimaatrisiko te verminder. Die doel van hierdie studie was om aanpassingsgeleenthede deur gepaste klimaatslim-boerderystelsels te identifiseer sodat die veerkragtigheid van die boere in die Mooifontein streek van die Noordwes-provinsie van Suid-Afrika, uitgebou kan word. Aangesien dit ’n landelike, landbougebaseerde ekonomie is, het die ondersoek gefokus op die risiko van klimaatsverandering op die plaaslike landbousektor.

Ramprisikoverminderingspraktisyns erken die belangrikheid van ’n goeie begrip van gevare soos klimaatsverandering binne ’n sosio-ekonomiese raamwerk, veral waar menslike aktiwiteite kwesbaarheidsvlakke vererger. Dit is dus belangrik om aanpassingsprosesse aan te wend om die veerkragtigheid van die lewe en bestaan van diegene wat die kwesbaarste is vir klimaatsveranderingrisiko, te verhoog. Dit behoort aangepak te word deur streektoepaslike aanpassingsprosesse wat deel vorm van die nasionale ontwikkelingsagendas. Verder moet gapings in kennis oorbrug word met kommunikasiestrategieë wat op multi-sektorale insigte gebaseer is, met die deelname van alle belanghebbendes, insluitende die geaffekteerde gemeenskap.

Die doel van hierdie studie was dus om voorbeelde van kennisoordrag en doeltreffende kommunikasiekanale vir toekomstige inisiatiewe te identifiseer. Hierdie doel word

vooropgestel deur die bewustheid dat enige ontwikkelingsbenadering wat gemeenskapsveerkragtigheid verhoog, afhang van die suksesvolle verspreiding van inligting.

Sleutelkonsepte:
Aanpassing; aanpassingkommunikasie; klimaatverandering; klimaatslim-landbou; bewaringslandbou; selfredsaamheid; ramprisikovermindering; versagting; veerkragtigheid; kwesbaarheid.

## DECLARATION

I, Jennifer Ann Mathews, hereby declare that the work in this mini-dissertation is my own, and that it is based on original research work that I conducted. I affirm that it has not been submitted elsewhere for the purpose of obtaining a degree or diploma, either in part or in full.

Signature of student

Date: 21 November 2016

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*"Though the fig tree may not blossom, Nor fruit be on the vines; Though the labour of the olive may fail, And the fields yield no food; Though the flock may be cut off from the fold, And there be no herd in the stalls - Yet I will rejoice in the Lord, I will joy in the God of my salvation. The Lord God is my strength; He will make my feet like deer's feet, And He will make me walk on my high hills"*
*Habakkuk 3:17-19.*

# LIST OF ABBREVIATIONS

| | |
|---|---|
| ACDS | African Centre for Disaster Studies |
| ACPC | African Climate Policy Centre |
| AGRICOR | Agricultural Development Corporation |
| AGRI SA | Agri South Africa |
| ARC | Agricultural Research Council |
| BFAP | Bureau for Food and Agricultural Policy |
| CA | Conservation agriculture |
| CCA | Climate change adaptation |
| CSA | Climate-smart Agriculture |
| DEA | Department of Environmental Affairs |
| DM | Disaster management |
| DRM | Disaster risk management |
| DRR | Disaster risk reduction |
| DWA | Department of Water Affairs |
| FAO | Food and Agricultural Organisation |
| FDP | Farmer development program |
| GHG's | Greenhouse gasses |
| Grain SA | Grain South Africa |
| HFA | Hyogo Framework for Action |
| IDNDR | International Decade for Natural Disaster Reduction |
| IPCC | Intergovernmental Panel on Climate Change |
| ISDR | International Strategy for Disaster Reduction |
| LTAS | Long Term Adaptation Scenarios |
| NMMDM | Ngaka Modiri Molema District Municipality |
| NWP | North West province |
| NWPG | North West Provincial Government |
| SAWS | South African Weather Services |
| SFDRR | Sendai Framework for Disaster Risk Reduction |
| UN | United Nations |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNMP | United Nation Millennium Project |
| WRC | Water Research Commission |

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# CHAPTER ONE: INTRODUCTION AND ORIENTATION

## 1.1 INTRODUCTION

In recent decades, climate change has been identified as a major environmental issue and a disaster risk that contributes to the increased vulnerability of communities worldwide. Although there is much debate about the true nature of this phenomenon, the Intergovernmental Panel on Climate Change (IPCC) asserts that climate change can be identified where there are changes to the mean that persisted over an extended period (IPCC, 2012:3). These could be the result of either natural processes or industrial and developmental activities that affect the atmosphere or land use patterns.

Disaster risk reduction (DRR) practitioners have identified the need to pay attention to the effect that climate change will have on communities. This is important in order to mitigate its negative effects by planning adaptation strategies to enhance the coping abilities of communities. The increasing severity and occurrence of extreme events is likely to contribute to increasing the numbers of vulnerable people and communities, and further heighten their level of vulnerability, particularly so for those communities already living at risk (Wisner *et al.,* 2012:210). The measurement of the magnitude of the economic impact of climate change on agriculture is challenging but red flags are raised by predictions that sub-Saharan Africa, a region characterised by communities that are highly dependent on agriculture and the slow adoption of modern technology, is likely to experience high temperatures and low rainfall (Kurukulasuriya *et al.,* 2006:368). Closer to home, a disaster risk management (DRM) review of the South African agricultural sector indicates that significant changes are predicted for South Africa over the next 50 years (Van Zyl, 2006). A warming of the African continent of between 1°C and 3°C, with maximum increases in arid regions and the minimum increased at the coast, are anticipated. Rainfall levels, anticipated to be between 5% and 10% less than current rainfall levels, will significantly reduce. Daily maximum temperatures in summer and autumn in the western half of the country will rise and there will be extended summer season characteristics, with some areas prone to increases in the occurrence of droughts and floods (Van Zyl, 2006:87). The adverse effects of climate change were

addressed at the 2008 Agri South Africa's (Agri SA) Congress (Vogel, 2008). The risk to Africa's small-scale farmers, usually the most vulnerable stakeholders in the sector, with low adaptive capacity and coping with multiple stresses, was also emphasised (Vogel, 2008). Vogel (2008) calls for focus on identifying adaptation strategies and insists that best practice agriculture for climate risk reduction should be taught to farmers to build resilience and ensure sustainable livelihoods.

The tendency to focus on the technological aspects of climate change distracts from potential interconnections with people who could assist in finding solutions because current research is still primarily focused on emission mitigation. There should be more focus on development and adaptation to climate change since "people can't eat information – they can only use it to help manage their risks and adjust their livelihood activities to respond to climate stresses and shocks" (Vogel & O'Brien, 2006:119). Wisner *et al.,* (2012:1) support this opinion stating that DRR should no longer occur within "institutional silos" but become a multi-sectoral effort.

A major concern is that, in spite of increased levels of awareness about the negative impacts of climate change, it is kept on the periphery of many development planning agendas so "social resilience is not improving" (Washington *et al.,* 2004:8). In light of the growing world population, which is likely to increase by one-third by 2050 and, with most of the additional two billion people likely to be living in developing countries, agriculture will need to transform itself. The Food and Agriculture Organisation (FAO) expects that agricultural production will have to increase by as much as 60% by 2050 to satisfy the growing demand for food and feed (FAO, 2013a:ix).

There are two very distinct approaches to climate change, with the most attention on mitigation efforts that focus on energy efficiency, reducing deforestation and lowering waste output levels, among other activities that are mainly reactive in nature (FAO, 2009b:37; Stern, 2006:iv). In this study adaptation practices were explored in an attempt to discover an appropriate DRR approach and describe a more relevant, albeit long-term approach to improve the lives of the rural communities living in South Africa. This new approach to development focuses on the dissemination of information and increasing the preparedness of communities at risk. Vogel (2008:16) believes it is necessary to twin adaptation and development with policy and strategy to better link

development and planning efforts. This includes approaches that examine appropriate farm size, veld management, carrying capacity and stocking rates, as well as strategies that include learning to live with drought. It is imperative that agriculture becomes better positioned to be more resilient to climate variability, as well as to position institutional policy towards risk reduction.

"Climate-smart agriculture" (CSA), has been explored as a tool for DRR since it has become apparent that new ways of farming must be identified to build resilience and ensure sustainable livelihoods. New management approaches are necessary for sustainable utilisation of natural resources such as land, water, soil and soil nutrition. Improved efficiencies for resource utilisation, including the efficient use of inputs and finances used for optimum production, must be identified (FAO, 2010:1). Some key components of a CSA farming system are a focus on soil and nutrition management, water harvesting and water usage, pest and disease control, resilient ecosystems and genetic resources. Production systems need careful selection and only practices suitable for the location should be implemented. A body of evidence exists to confirm that considerable gains are to be made through the selection of suitable crops, varieties and breeds (FAO, 2010:1). There are several examples of alternative farming systems with the potential to reduce net greenhouse gas (GHG) emissions and stabilise or increase production in spite of extreme weather patterns (Beddington *et al.,* 2012b:3). Five million hectares of agro-forestry in Niger, of benefit to 1.25 million households, have sequestered carbon resulting in increased grain yields (Braimoh, 2012:37). There are still too many cases where costly inputs and labour are ploughed into farming operations but the endeavours came to nought, either because the soil was undernourished, the time of planting was off or the weeds had grown taller than the crop. The manager of Grain South Africa's (Grain SA's) Farmer Development Programme (FDP) has advised that messages about best practice and timeliness of operations have to be repeated often (McPherson, 2013a:3).

The shift to climate-smart farming will require education and commitment from the farmers, but adequate institutional support and incentives that support the practical transitions are also necessary. It is also acknowledged that there are knowledge gaps with respect to the suitability and application of new production systems, and practices

across a wide variety of agro-ecological and socioeconomic contexts and scales (FAO, 2010:4).

A general objective of this research was to identify the most appropriate CSA practices for the Mooifontein region in the NWP of South Africa. This is necessary in order to increase the coping capacity of the farmers in this region, through adaptation and the adoption of best practice for climate risk management. It is also acknowledged that no adaptation will be sustained without the full participation of community members, who need to understand the reasons for adaptation. It is vital that they be included in any process that is posited as a solution for the sustainability of their lives and livelihoods. The path of development requires that a bridge be built between local knowledge and scientific knowledge, since it is the people themselves who are immersed in living their lives with the impacts of climate change, so it is they who most need knowledge and information about how to cope (FAO, 2009a:2,5).

## 1.2 ORIENTATION

The Mooifontein region of the North West province (NWP) straddles the defunct border of what was once the former homeland of Bophuthatswana and South Africa. A large part of the area of study falls within the Ngaka Modiri Molema District Municipality (NMMDM) while other farmlands fall under the Lichtenburg District Municipality. The specific field of study is identified as the site blocked out in red in Figure 1.1.

Mooifontein village is a regional hub, and has a South African Police Service office, a satellite office of the Department of Agriculture and Rural Development, and a state veterinary office. The remains of the defunct Central Primary Agricultural Co-operative are still there, currently leased by a local maize milling operation. The Kopano Tribal Authority, which also services satellite villages in the region, is situated in the village of Mooifontein.

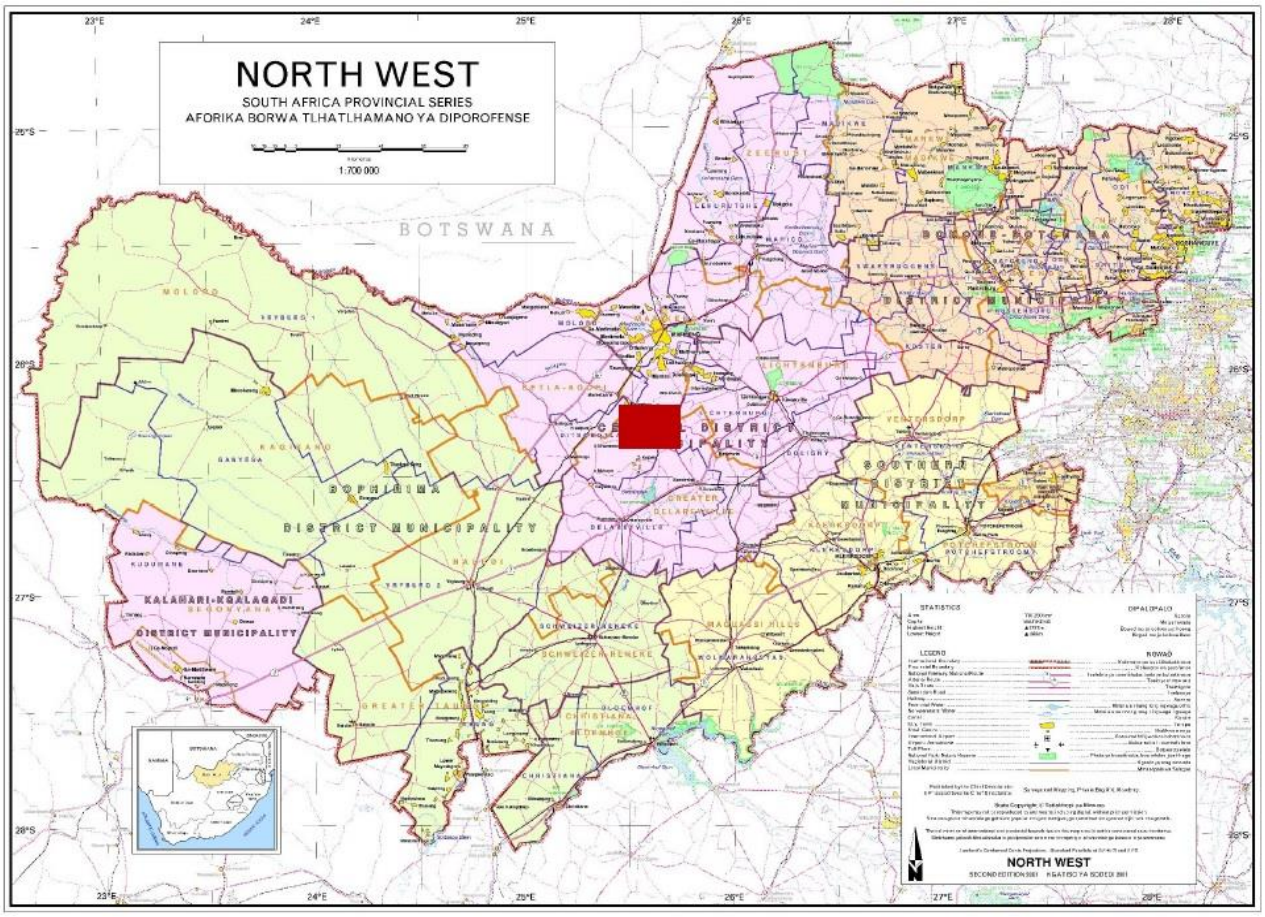


Figure 1.1: Contextualising the area of study within the North West province (Map courtesy of NWK).

Each of the settlements is surrounded by high-potential arable lands and areas of commonage used primarily for grazing livestock, as seen in Figure 1.2. The crops grown in the region are predominantly maize, a local staple food, and sunflowers, as well as groundnuts, beans and a small component of grain sorghum. The livestock component comprises primarily cattle, with some sheep and goats, as well as poultry belonging to farmers who either raise broilers or produce eggs. The farmlands which have always fallen inside South Africa are large-scale commercialised cropping and livestock farming operations.

Much of the region that falls inside the old Bophuthatswana homeland territory has been farmed under traditional tenure (Kirsten & Van Rooyen, 2011:269) by small-scale and developing farmers for years. These farmlands were included in the Bophuthatswana homeland's agricultural development strategy and benefited from high

levels of investment in the region. The project was managed by the parastatal Agricultural Development Corporation (Agricor), with the support of Agribank. These farming operations took place from around 1978 until Agricor was disbanded when the new post-apartheid dispensation was inaugurated in 1994 (Kirsten & Van Rooyen, 2011:270). During the Agricor era, it appeared as if the Mooifontein region would flourish and become a highly productive grain-growing region, which could have created opportunities for farmers and entrepreneurs alike. There was a flourishing Central Primary Co-operative that offered a diverse range of support services, including access to finance and insurance, mechanisation and production loans, and extension support. With the demise of Agricor this golden era ended and today the region is in an economic slump. It is clear that the planned farmer development was a failure. This has been attributed to Agricor agents doing the job "*for* the people rather than *with* the people", with the result that knowledge and skills were neither transferred nor sustainable (Bachtiar *et al.*, 2003:25).

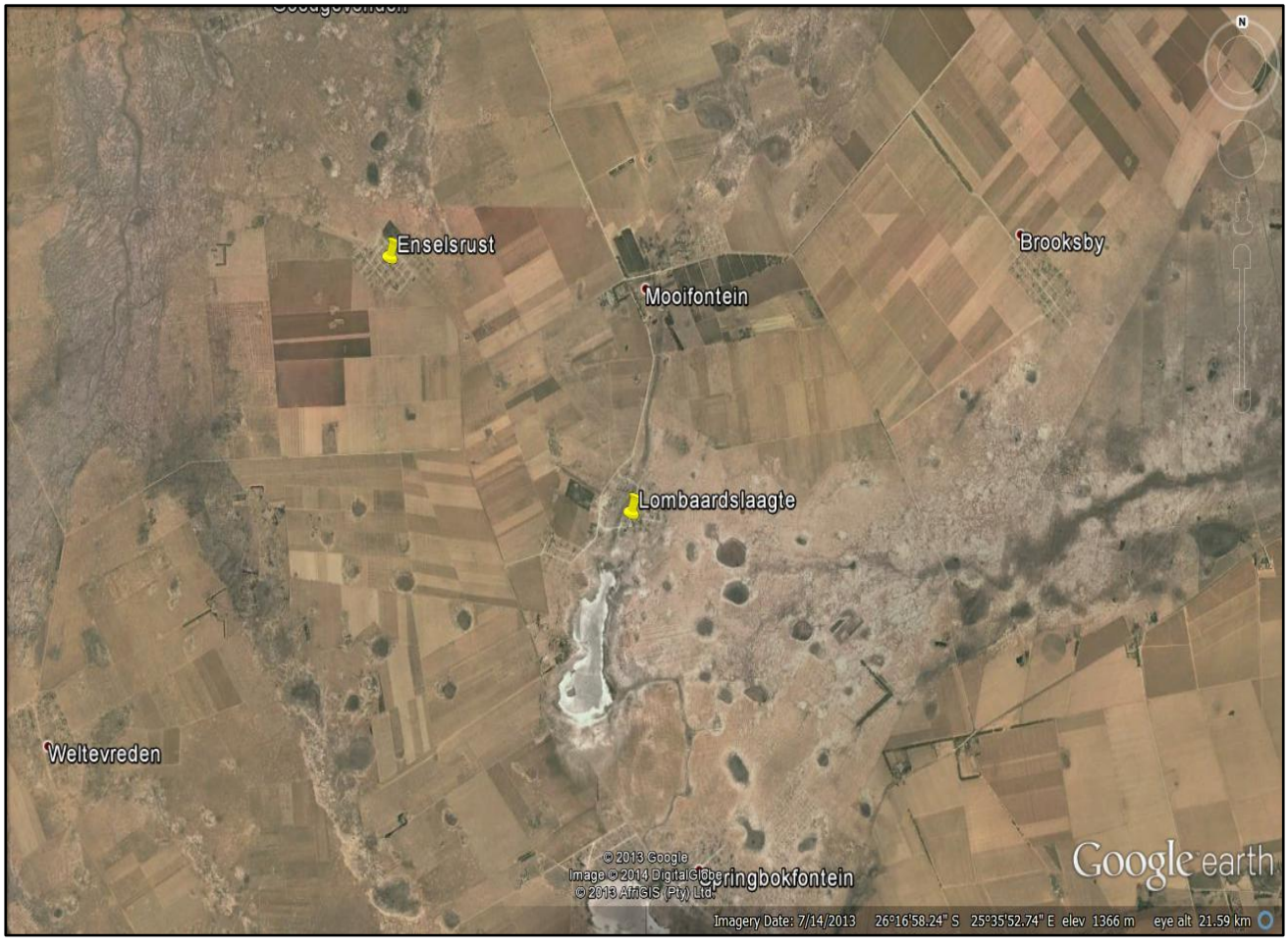


Figure 1.2: Aerial view of the Mooifontein region, Ngaka Modiri Molema District Municipality (Source: Google Earth).

The land utilised for the Agricor project was returned to the farmers by the Bophuthatswana government after 1994. An unknown number of farms in the region were transferred to black beneficiaries under the land reform scheme, while some of the farmlands were handed to beneficiaries under the Proactive Land Acquisition Strategy (PLAS) scheme (Kirsten & Van Rooyen, 2011:269). All these farmers have experienced years of challenges resulting from droughts, variability in the seasonal norms, and a lack of access to finance for inputs and crop insurances.

Reports indicate that NWP's agricultural sector needs intervention to remedy a situation which is characterised by decreasing employment, low income, and high poverty and inequality levels (Jacobs *et al.*, 2009:i). The Integrated Development Plan NMMDM 2012-2016, reported serious development challenges in the district, which had poor infrastructure, was underserviced and had widely dispersed settlements (NMMDM, 2012:30). The unemployment rate was 10% higher than the national average (NMMDM, 2012:29) and there were high levels of poverty and hunger, which the district hoped to counter by prioritising agricultural development (NMMDM, 2012:57). The challenge is that farming in this region is capital intensive, which has resulted in many 15ha portions of land, which were given to beneficiaries through the land reform scheme, being left lying bare. Some progressive small-scale farmers have leased 15ha plots to expand their farming operations, while other plots are sharecropped by commercial farmers in the region, who pay the landowner either in cash up front or a share of the crop (Mathews, 2013). Thus far, the commercial farmers' levels of financial independence have enabled them to maintain viable businesses and have more options for securing their farming enterprises. This is reflected in the diversification strategies employed by commercial farmers in terms of "investment, income and assets". They have also been more mobile and flexible which has enabled them to select better soils and move out of marginal areas (Bernstein, 2013:27).

Figure 1.2 highlights the field of study and covers approximately 10 000 ha. The nine farmers interviewed for the empirical study run farming operations from 100 ha to 2000 ha in size. Together these farmers work about 50% of the area highlighted. They are well represented on all the ploughed fields seen in this aerial map while some of the farmers also utilise the commonage rangelands for their livestock. There are a few other small operators farming units as small as 15 ha in the region but they were not

interviewed since the study focussed on the bigger operators whose units are more viable and economically sustainable in the long term. The remainder of the region is either commonage which is used to run livestock or left unproductive because although undoubtedly there are many other 'would-be' farmers in the region who would love to farm, they can't due to financial pressures and an absence of support.

There is a need to investigate the detrimental effect that climate variations could have over time on a region already dealing with complex stressors that inhibit producers from farming sustainably. If there are suitable climate-smart solutions and adaptation practices, then these need to be identified and motivated through every available channel of communication until they are incorporated into regional DRR strategy.

## 1.3 PROBLEM STATEMENT

Climate changes have been observed in the past five decades and are highly likely to have adverse effects on South African agriculture, with repercussions for rural and vulnerable communities (DEA, 2013:128). The long-term climate trends and scenarios (LTAS) predicted for Mooifontein (Zone 3) suggest general drying from 2015 to 2035, with annual temperatures increasing by up to 2.5°C, and a negative annual rainfall, with the mid-future period from 2040 to 2060 showing projected increases in temperatures of up to 5°C. From 2080 to 2100, there will be drastic increases in annual mean temperatures of up to 6.5°C - "reaching a regime never observed before in the recorded climate of the region" (DEA, 2013:120-121).

The farmers of southern Africa are largely resource-poor and live with a range of problems such as HIV/AIDS and insecure land tenure, as well as climate risk. These periods of climate stress include prolonged periods of drought (Reid & Vogel, 2006:195). Smallholder farming in South Africa is an impoverished sector, with up to 2.5 million households characterised by low productivity and ineffective support in terms of extension, finance and marketing services (Van Zyl, 2006:89). However, whether they farm one hectare or 1000ha, all farmers need knowledge and skills. This is why Grain SA's FDP strives to develop capacitated commercial grain farmers who can make a contribution to household and national food security through the optimal use of the resources at their disposal (McPherson, 2013b:20). Common problems identified are:

- soil erosion;
- inappropriate soil use;
- mono-culture farming practices;
- low pH in the soils;
- poor equipment;
- poor soil preparation;
- plough pans;
- using non-hybrid seed;
- no fertilisation;
- no weed control; and
- challenges to access markets.

Other challenges relate to the different systems of land tenure and lack of security. The absence of title ownership common to many farmers in South Africa means it is difficult to source production finance. Many farmers share equipment under government grant schemes, which creates tensions since the timing of operations is often critical. Emerging farmers have much to learn about the intricacies of farming and need support on issues ranging from basic best practices to advanced production planning and financial management (McPherson, 2011:1,2).

Climate-smart agriculture contributes to the three fundamental objectives of sustainable development, namely economic, social and environmental sustainability. These three dimensions are addressed through:

- sustainably increasing agricultural production;
- adapting and building resilience to climate change; and
- reducing or removing GHG's where possible (FAO, 2013a:ix).

Despite consensus that keystone strategies in the sector should be directed at CSA as a tool to enable adaptation, mitigation and development goals, it is important to ensure a common understanding and to synchronise how they should be implemented (Beddington *et al.*, 2012b:21,29). CSA is region-specific. This means the tools of hazard, vulnerability and capacity assessments in the standard DRR toolkit should be employed. Examples of successful CSA programmes were investigated, with a

particular focus on the approach at grass-roots level, in order to understand which programmes have been successful and why they were beneficial. The principles of conservation agriculture (CA) were explored as a farming system contributing to CSA, since minimum till and no till practices lead to reduced GHG emissions. CA practices build healthy soils and lead to more efficient management of water and nutrients (Powlson *et al.*, 2014:682). A CA approach is characterised by minimum soil disturbance by mechanisation, soil protection through permanent cover with organic matter, crop rotation and diversification.

In light of the above, this study has highlighted the importance of identifying CSA practices that could be incorporated into development initiatives. To focus only on climate risk will not adequately address inherent vulnerabilities, since diverse and complex factors influence the environment of South African farmer development. At the same time, to neglect to address climate risk will most certainly increase levels of vulnerability. While one recognises the complexity of the challenges facing farmer development initiatives, it is imperative to highlight the interconnectedness of climate change and variability, increased knowledge of climate risk, vulnerability and the need for an integrated plan to increase the region's coping capacity through adaptation and preparedness.

In the following section the critical questions that needed to be asked in order to achieve the goals of this study are noted.

## 1.4 RESEARCH QUESTIONS

Since it is anticipated that climate change will affect farmers adversely by making their livelihoods more fragile and precarious, it was necessary to discover the level of vulnerability of the farmers in the Mooifontein region and then consider their adaptation needs. The key questions which begged to be answered by this study therefore were:

1. What influence does climate change have on the agricultural sector?
2. How well developed are the levels of awareness of climate change as a phenomenon in the Mooifontein region?

3. What are the theoretical approaches and perspectives on climate change and DRR, and which links can be established between the two schools in the context of farmer development and vulnerability?
4. What are the current climate change policies and legislation in South Africa?
5. What is climate-smart agriculture?
6. Why is it important to transfer knowledge that will both inform and encourage farmers to be prepared to make changes and ensure that they understand the benefits of climate-smart agriculture?
7. What is the nature of land ownership or access to farmland, what is produced by the farmers and what are the predominant traditional agricultural practices in the region?
8. What would a successful adaptation education programme look like?

## 1.5 RESEARCH OBJECTIVES

The focus of this research was on specific objectives to highlight the diversity and complexity of the many aspects of climate change in agriculture in order to arrive at a full understanding of climate change and the possible effects it might have on agricultural activities and production in the Mooifontein region.

### 1.5.1 General objectives

The main objective of this study was to analyse climate change and its effect(s) on the agricultural sector in the Mooifontein region. The aim was to identify relevant adaptation solutions to enable the researcher to make recommendations that would address the issues of CSA. Furthermore, the intention was to inform all stakeholders of the value of adopting CSA to increase resilience in the region. McPherson (2011:7) claims that there is a significant amount of training material in place that is “not appropriate to the needs and level of the farmers”. It was also a goal of this study to explore region-appropriate CSA to inform local adaptation education initiatives.

### 1.5.2 Specific objectives

The following specific objectives informed the research:

- An exploration and description of the phenomenon of climate change and its influence on the agricultural sector;
- A study of the interconnectedness between climate change and DRR, and the links between the two in the context of farmer development and livelihood vulnerability;
- A study of what climate-smart agriculture is;
- To determine the relevance of knowledge transfer and education about CSA in farmer development programmes;
- To determine the status of current climate change legislation and policy in South Africa;
- To analyse land ownership and access to farmland and then evaluate and discuss production activities, as well as traditional agricultural practices in the region;
- To evaluate and discuss the levels of awareness of climate change in the region; and
- To make recommendations for the development of an appropriate adaptation education programme for farmer development in the region.

## 1.6 CENTRAL THEORETICAL STATEMENTS

The field of climate change science is complex and dynamic. The focus of this study was the theory of climate change as an adaptation challenge. The impacts of climate change are likely to increase levels of vulnerability in some communities, so their coping capacity needs to be improved. In this study, the theory of resilience was examined and processes for building resilience into communities were explored within the context of a DRM approach. There is a need to identify interconnections that could add value to addressing the climate change problem and the way information is networked and dispersed (Vogel & O'Brien, 2006:116). This researcher aimed to achieve this within the framework of the specific climate risks faced by the Mooifontein farmers. Climate change and DRR communities have previously operated

independently of one another, but both disciplines have similar aims, so collaboration would be mutually beneficial (Venton & La Trobe, 2008:1).

Some solutions for climate change risk already exist, while others still need to be discovered. CSA embraces modern technology and other advances in the agricultural sector in seeking improved production potential for example, through appropriate fertilisation programmes, the efficient use of pesticides, planting high yielding seed varieties, and also by examining land management practices and wise water management processes. Careful analysis of traditional farming systems needs to be done to assess whether there are likely to be detrimental effects on resources if there is no adaptation, i.e. if business continues as usual. Unsustainable farming practices are common in rural South Africa and have led to poor yields and low profits, which have resulted in a decline in hectares planted (Mathews, 2013). This in turn compromises food security, particularly at household level. CSA embraces CA as one way of adapting to climate change and reducing crop risks. CA practices result in soils being cooler, less moisture is lost through evaporation and the water in the soil is used more efficiently to benefit the plants (FAO, 2010:5).

In order to achieve the aims of this study and to support these theoretical statements in such a way that they might be found acceptable to the scientific community, this study was structured according to accepted research procedures. These will be described in the next section.

## 1.7 RESEARCH METHODOLOGY

In this section the focus is on the research design of this study as well as the research methodology employed to achieve the objectives of the research inquiry that were stated earlier in this chapter.

The research methodology used in this study was based on inductive reasoning. This means the researcher begins with observations of the empirical world rather than any particular pre-established truth or assumption (De Vos *et al.*, 2011:49). This was appropriate in this instance because there had been an observation that climate change

has influenced agriculture and is likely to do so even more in the future. Detailed investigation is followed by analysis and findings that inform “theoretical concepts and propositions” (De Vos *et al.*, 2011:49) as was the case in this study too.

This inquiry followed a qualitative research approach which, according to Gibbs (2007:x), is no longer merely “*not* quantitative research” but rather research that has an own identity or even a “multiplicity” of identities. Qualitative research is not conducted in a structured environment such as a laboratory, but requires the researcher to go into the field and immerse him- or herself in the real world in order to “understand, describe and sometimes explain social phenomena from the inside” (Gibbs, 2007:x). Taylor and Bogdan (1998:7) state that qualitative research is inductive, since qualitative researchers develop concepts and gain insight from patterns that emerge in the collected data, rather than in the scenario in which researchers collect data to assess preconceived models or theories.

### 1.7.1 Research procedures

Two key aspects of this research design, namely the literature review and the empirical study will be described below.

#### 1.7.1.1 Literature review

An in-depth investigation into the existing body of scholarly and academic work was done in order to discover what has already been learnt about issues pertaining to DRM and climate change as it relates to agriculture. A desktop survey was conducted using the internet and search engines such as Google and the databases NEXUS, EBSCOhost, Scopus and Science Direct. Further reading was done using books, journal articles, recognised academic theses and dissertations, and also technical journals from the world of agriculture and disaster risk management bodies such as SA Grain, Harvest SA, Pula Imvula and Jamba. The African Centre for Disaster Studies’ (ACDS) Knowledge Shop was also used as a source of expert information.

#### 1.7.1.2 Empirical study

The survey procedure that was followed in pursuit of gaining knowledge by means of direct observation and experience is described in this section. The study was exploratory and descriptive in nature, and phenomenological methodology was used in

an attempt to understand the stakeholders' experiences of the phenomenon of climate change, since the most important reality is that which people perceive it to be (Taylor & Bogdan, 1998:3). The phenomenological perspective concerns what people experience, what they say and what they do (Taylor & Bogdan, 1998:11).

#### 1.7.1.2.1 Research design

It is true that all empirical research has an implicit albeit not explicit design, so it is important to make the design explicit "to get it out in the open, where its strengths, limitations and consequences can be clearly understood" (Maxwell, 2013:3).

A qualitative approach was adopted for this study and therefore the research design was characterised by an inductive, open-ended strategy. The qualitative research design was appropriate for this study since it is especially suited for gathering social data in pursuit of understanding socioeconomic aspects of life. Qualitative researchers usually collect data in the field, at the site at which the participants experience the issue or problem under study (Creswell, 2009:175), and this was the course of action followed for this research. In a qualitative study the research design is essentially a dynamic process of continuous reflection that occurs throughout the project. This means that the activities of data collection and data analysis can possibly lead to new and refocused questions, and the researcher will "construct and reconstruct" the research design (Maxwell, 2013:3). According to Taylor and Bogdan (1998:26-27), qualitative researchers typically define their samples on "an on-going basis" since one does not altogether know which lines of enquiry will be the most fruitful until one is engaged in a study.

#### 1.7.1.2.2 Research setting

Mooifontein is the hub of a farming region covering approximately 10 000ha that includes the villages of Brooksby, Mooifontein, Lombaardslaagte, Deelpan, Enselrus, Weltevrede and Uitkyk. The setting has already been described in detail in the Orientation (see Section 1.2 above). A research setting should be easily accessible and it should be possible to establish an immediate rapport with the respondents (Taylor & Bogdan, 1998:27). Since the researcher lives in the immediate community this was easily addressed. Access to the community via the key gatekeepers (Taylor & Bogdan,

1998:29) was possible because key community leaders are known to the researcher. The researcher was already involved in farmer development so the motivation to explore the concept of adaptation education for a specific agricultural community in the Mooifontein region of the NWP acted as an impetus for this study.

#### 1.7.1.2.3 Sampling

Sampling is a popular strategy of data collection for qualitative studies (Hoepfl, 1997:51). The rationales behind participant selection and sample size are discussed next.

- Participant selection

  It was not possible to consult with every local farmer and expert in the field; therefore a selection process was used to ensure accurate representation of the broader community. Two sampling procedures were employed in the data collection process.

  The primary sampling process was stratified, purposeful sampling (Struwig & Stead, 2001:123), employed to select participants from different groups. Creswell (2009:178) explains that the idea behind qualitative research is to purposefully select participants who will best help the researcher understand the problem. Therefore purposeful judgements were made and the researcher used her knowledge and insight to select a sample of participants for this study. Within the context of this study, representation was sought from the spectrum of stakeholders engaged in farming activities in the region namely:

  - Small-scale farmers;
  - Male, female, young and old farmers;
  - Commercial farmers; and
  - Agricultural experts.

  This fulfilled the purpose of ensuring the representation of all levels of the agricultural community.

  A secondary snowball sampling process (Struwig & Stead, 2001:123) was used in support of the first procedure in pursuit of “information-rich cases” to add depth to

the study (Hoepfl, 1997:51). Two additional interviews resulted: 1) A farmer participant invited his father to the interview. He felt he would have valuable insights about changes in climate because he had been an active farmer for more than 20 years, and 2) A farmer recommended contact with a plant production expert based at a seed company in Lichtenburg. The researcher deemed this meeting relevant since the specialist was a young female scientist who could have added fresh perspectives to the study.

- Sample size

  It is difficult to conclusively determine the sample size right from the outset of a qualitative study since "qualitative researchers are more interested in whether the information from the sample is rich in data and thick in description than the extent to which the sample's data can generalise to the population" (Struwig & Stead, 2001:125). The rule of thumb for the purpose of the research was to conduct interviews with 10 farmers and when it appeared there could be other useful interviewees, these were approached. Once the researcher recognises there is no longer new data emerging from the research process, it can be said that a point of saturation has been reached (Houghton *et al.*, 2013:13). With this as a guideline, data collection was halted once it became clear that a saturation point had been reached and no new insights were coming to light. Interviews were also conducted with five experts knowledgeable about agriculture in the Mooifontein region.

#### 1.7.1.2.4 Data collection methods

A number of data collection methods were employed, such as interviews, observations and a document search, since "qualitative researchers typically gather multiple forms of data" (Creswell, 2009:175). As Maxwell (2013:102) indicates, the research questions formulate what one wants to understand, but it is through the collection and interview process that one gains understanding.

Data collection was done on an on-going basis and involved:

- Non-participant field observations: According to Struwig and Stead (2001:100), observation in qualitative research occurs in an unstructured manner within the natural setting of the study. A feature of the observation process is that the

researcher scans the field whilst participants continue with daily activities, unaware that someone is observing and looking for trends and patterns to add depth to their research. Observation may include the use of tools such as cameras, binoculars or recorders to collect data, but it may also employ none of these (Struwig & Stead, 2001:101). Data gathered by watching "from the outside", may be used to provide rich description of people, place and general activity in the field of survey (Hoepfl, 1997:53).

- Semi-structured personal interviews: Semi-structured interviews were conducted with the participants as part of the empirical research process. A semi-structured interview implies that the researcher will have a set of pre-determined questions to act as a guide. The questions are merely intended to be a supportive tool for the interviewer so they do not imply a fixed interview format nor do they dictate the course of the encounter as they would in a formal interview process. Rather the researcher will use the questions to guide the process, which might evolve along an unexpected path of discussion when interesting insights arise (De Vos *et al.,* 2011:352). Thus, a set of questions were formulated based on the literature review, but the participants were encouraged to express their own experiences and insights during the interviews. The questions designed for the purpose of this research can be viewed in Appendices A and B. This process proved to be conducive to enabling the participants to tell their own stories (De Vos *et al.*, 2011:343). The researcher arranged for a translation service to bridge the language barrier, but these services were not required as the interviewees were all competent in either English or Afrikaans so there was no danger of miscommunication or misinterpretation which may have compromised the data collection process.

- Field notes: Observation of the setting and occasional encounters with some of the participants took place between July 2013 and November 2016 with the intention of equipping the researcher with rich insights and thick descriptions for the purposes of this study. The researcher made field notes about the environment and the activities of farmers in the region of study (Creswell, 2009:181). Detailed field notes were also recorded after face-to-face encounters because everything seen or heard in the field was considered to be a potentially

valuable item of information (Taylor & Bogdan, 1998:67). This is important because De Vos *et al.,* (2011:329) believe that "serendipity is important in participant observation", and field researchers might realise the particular importance of something they have observed only at a much later stage.

- Document study: This was particularly useful where historical events and experience have relevance (De Vos *et al.*, 2011:377). The researcher learned of the existence of historic rainfall records for the region (see Appendix C) and was able to read the personal diarised entries of the first official rainfall observer in the region, Mr T. A. Young (see Appendix D); and

- Photographs: The researcher was able to take photographs to add to the rich description of the field of study.

Data collection was followed by a data analysis process during which the findings were coded and grouped into themes until patterns were identified for discussion.

#### 1.7.1.2.5 Data analysis

The qualitative data analysis was based on an interpretative philosophy aimed at examining meanings and the symbolic content of the data (Maree, 2007:99). All the data collected was transformed into meaningful patterns in order to produce findings for the study - a process of digging deeper, rather like "peeling back the layers of an onion" (Creswell, 2009:183). The method of analysis of the interviews was based on a thematic and content analysis, since the words of the text were classified into content categories (Struwig & Stead, 2001:14) in order to describe and interpret the participants' views. The interviews were extrapolated and, through a process of memo making, categorising and coding, emerging themes were identified. Creswell (2009:175) asserts that qualitative researchers "build their patterns, categories and themes from the bottom up" in a methodical process in which data is rearranged. Memos are brief words, noting key ideas or concepts that lead the coding process, while categories are generated when recurrent themes appear in the data. This process "involves reducing the data to a small, manageable set of themes to write into the final narrative" (De Vos *et al.*, 2011:410).

#### 1.7.1.2.6 Reliability and validity

In qualitative research, information is commonly collected using multiple methods and this serves as a useful cross-checking strategy known as “the triangulation of data” (Taylor & Bogdan, 1998:80). Gibbs (2007:94) asserts that by collecting more than one view on a subject, a more accurate view of the subject matter is obtained. This process is essentially a safety net that ensures accuracy and prevents biases that could arise if only one method of data collection was employed.

#### 1.7.1.2.7 Researcher’s role

It was the responsibility of the researcher to present herself in a way that instilled confidence and assured participants that they could trust the process. The purpose of the study was explained so that the participants fully understood the drivers behind the research. The “researcher effect” is recognised in that the researcher could possibly have had an effect on the setting and could influence or be influenced by the setting (Cloete, 2007:519). It was up to the researcher to ensure that no biases affected the information and skewed the results. Cloete (2007:520) says this can be achieved by spending enough time on site, clearly communicating one’s mandate, enlisting the help of an informant on site, using the triangulation method, sharing one’s field notes with another more objective researcher and keeping the research questions in mind all the time.

#### 1.7.1.2.8 Ethical considerations

It was important that the participants’ observations be kept authentic and that their personal privacy was never compromised. The vision was always that the research could benefit the participants and their community, and the guiding principles were respect for the individuals and community being researched, underpinned by the philosophy: “First do no harm”.

The nature of the enquiry did not require any deep psychological disclosure but rather sought to discover levels of knowledge within the community about climate change and variability, and to learn more about the farming systems in practice and whether there were levels of awareness about adaptation. The successful identification of appropriate adaptation procedures, combined with an appropriate educational strategy for the

farmers, could give this study meaning and relevance and could make it a significant contribution to agriculture in the Mooifontein region.

## 1.8 SIGNIFICANCE OF THE STUDY

In light of the potentially disastrous implications of adverse climate change and variability, it was deemed necessary to identify the nature of the hazards that might impact the Mooifontein region. A major objective of the study was to make recommendations on region-appropriate climate-smart farming methods for policy makers, educators and development practitioners working with farmers whose livelihoods could become precarious if ignorance of risks and of adaptation and climate-smart farming persisted. The significance of the study will be evident in the recommendations on best practices for climate-smart agriculture in the Mooifontein region. This could add value to the process of seeking to ensure sustainable livelihoods by adopting a fresh approach to farmer development initiatives.

## 1.9 CHAPTER LAYOUT

In this section a brief description will be given of the content of each chapter.

Chapter 1: This chapter comprises the orientation and rationale for the study. The problem statement is outlined and a justification for why the topic was worthy of investigation is provided. Research objectives, research questions and the research methodology were also described.

Chapter 2: Literature relating to theories about climate change and variability is reviewed in this chapter. The theory of climate change as it relates to agriculture, and small-scale and emerging farmers, is noted. Particular attention is paid to the literature that looks beyond climate mitigation to recognise the important role that adaptation can play as a tool for DRR in agriculture. Since community resilience can be built through

strengthened knowledge systems, knowledge transfer processes were also investigated.

Chapter 3: International and national policies and legislative frameworks on climate change are analysed in order to establish the intent and vision of policy makers and to benchmark these against the research findings regarding experience at grassroots level within the context of the regional study. A review of climate change management in the agricultural sector as it is currently entrenched in the legislation and policy frameworks in South Africa is conducted.

Chapter 4: This chapter is comprised of a discussion and interpretation of the empirical findings of this study. This includes an analysis of the perceptions of the small scale, emerging and commercial farmers, as well as the selected group of agricultural experts and stakeholders.

Chapter 5: This chapter concludes the study with a final discussion and conclusions. Some recommendations that relate to risk management and adaptation strategies that are likely to contribute to the reduction of the Mooifontein farmers' vulnerability levels are highlighted for possible inclusion into development and adaptation education programs for the sector.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 INTRODUCTION

The climate is changing and this presents challenges for leaders of nations, industries and development agencies, as well as for communities and individuals, since climate stress further threatens the livelihoods of already vulnerable communities (Reid & Vogel, 2006:195).

Climate change is a high-profile environmental concern that is likely to have a profound impact on "natural" and human systems (Wisner *et al.*, 2012:207). Climate change theories have been the subject of much debate and counter argument, with some scientists going so far as to call it a "war" which has drifted too far away from actual "scientific enterprise" (Berry *et al.,* 2016:607). Even the influential IPCC has been criticised for being "an activist enterprise" with an "agenda to justify control of the emission of greenhouse gases" and the contention that the IPCC "was a political rather than a scientific entity" has the support of many (Idso & Singer, 2009:iv,v). Salinger (2005:27) argues that "climate variability and change have gone on throughout time" in part due to phenomenon such as the Interdecadal Pacific Oscillation (IPO) and El Niño/Southern Oscillation (ENSO). He notes that historic climate patterns documented a cooler period for the Northern Hemisphere during the 19th century, but then the 20th century was characterised by rapid global warming with temperature variations "as much as 1°C globally". He observes that "history can provide very valuable lessons on effects of climatic variability on human dimensions" like society and economics and agriculture and forestry (Salinger, 2005:9). Salinger (2005:10) urges "if climatic variability in the order of 0.5° C can cause such a dramatic effect on glaciers, flood events and storm surges, agricultural commodity process, wine yields and other societal effects as documented for the 16th century" then it is critical that the potential impacts of increased climate variability and change in the 21st century be considered. Berry *et al.,* (2016:600) note that current climate change modelling has limitations which cannot accurately evaluate larger cycles of variability produced by natural processes in a broader climate system and suggest that models are not adequate enough to

influence policymaking to the extent they do. They also warn against the distractions which arise out of the debate, “there is also the critical need to address other aspects of the human condition, particularly in the developing world” (Berry, 2016:600).

It would be easy to lose sight of the risks that changes in climate pose for the agricultural sector and the implications thereof in the corridors of such commentary and power play. The focus of this study is building resilience to climate risk in the agricultural sector within a DRR context which requires that a particular situation is analysed, potential threats to the well-being of communities and the safety of their livelihoods must be identified, and solutions must be designed within existing development agendas. When considered within a South African context, where rural livelihoods are already vulnerable and subject to a multitude of shocks beyond the climate debate, it is important to recognise that climate variability is only one of many stresses rural communities must cope with e.g. HIV/AIDS has impacted rural livelihoods creating weaker household units that due to the illness are not strong enough to work and thus have lowered incomes. In this light the “growing evidence of global environmental change and increased climate variability demands that adaptation options, adaptive capacity and ways to reduce risk should be prioritised” (Ziervogel & Calder, 2003:403).

This chapter is comprised of a literature study on climate risk and the likely threats posed to the environment and sustainable development. It must be highlighted that this study is not only looking at climate change and greenhouse gas emissions (GHGs), but rather at a much bigger picture of climate risk which includes the broader concepts of climate variability, climate unpredictability as well as slow onset disasters which are called ‘creeping’ environmental problems or changes (CEPs). Together these are recognised as ‘global environmental change’ (GEC) (Wisner *et al*., 2012:207,209). The underlying question asks whether it is possible to build resilience to climate risk in the agricultural sector through a process of adaptation education using climate smart farming methods in the Mooifontein region of the North West province. For this reason, the vigorous debate about whether the phenomenon is climate change or climate variability or global warming or creeping change has not been the focus of the study. That argument is for another platform. The approach adopted here is founded on a DRR strategy which holds that regardless of what the ‘truth’ about the climate scenario

is, farmers still need to learn to face climate risks and could possible cope better by being enlightened about adaptation and climate smart farming. Literature on the emergence of the theory of climate smart agriculture will be studied and examples of where this theory has been put into practice will be reviewed. The IPCC (2014:18) lists five reasons for concern about the risk of climate change: 1) unique and threatened systems; 2) extreme weather events; 3) distribution of impacts; 4) global aggregate impacts and 5) large-scale singular events. These threats necessitate a change in the way we do things and calls for adaptation strategies to limit climate change risk and ensure sustainable livelihoods (IPCC, 2014:8).

Literature on the subject is reviewed with a particular focus on the impact of climate change on the agricultural sector. The known and anticipated effects on agricultural sustainability and the role of climate change mitigation and adaptation as a tool for DRR in the sector are investigated. Specific effort has been made to identify potential climate change impacts on the Mooifontein region and potential weaknesses there. The insights into the impacts of climate change on agriculture leads to a consideration of adaptation in agriculture and climate-smart farming (CSA) as an adaptation tool towards ensuring sustainable farming systems. Finally, since this should inform the design of appropriate DRR policies for integration into development programmes, the significance of adaptation education and knowledge sharing is examined.

## 2.2 CLIMATE CHANGE AND THE AGRICULTURAL SECTOR

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate that can be said to be the direct or indirect result of anthropogenic activity (Wisner *et al.,* 2012:207) that has caused rising GHG emissions to trap heat energy and disrupt natural climate patterns (UNFCCC, 2007:7). The UNFCCC also emphasises that climate change is directly linked to development (UNFCCC, 2007:7) and states that special attention should be paid to developing countries, which are most vulnerable to natural disasters. The Hyogo Framework for Action (HFA) 2005-2015 was explicit about the need to integrate climate change mitigation and adaptation into DRR processes (ISDR, 2005:15; Mitchell *et al.*, 2010:11). This study used the IPCC's definition of climate change, namely a change in climate

that persists for an extended period and is caused either by natural processes or human activity (IPCC, 2007:6; Wisner *et al.,* 2012:207).

In the following sections, global and regional perspectives of climate change impacts are examined, including an in-depth look at the nature of farming and the general characteristics of the farmers in the Mooifontein region.

### 2.2.1 An International Perspective

Climate change risk threatens to disrupt the traditional practices and livelihoods of all humankind, but in particular those of rural communities and those who earn their living from the land (IPCC, 2014:16,65). These people depend on their inherent knowledge of the seasons for decision making about land use, crop selection, planting dates and seasonal rainfall patterns (Iloka, 2016:2). Staple subsistence crops are already under pressure and yields have declined (FAO, 2008:12; Chauvin *et al.*, 2012:1). Unpredictable and erratic rainfall patterns and shifts in seasons, along with increased salt levels in both the soil and water supplies threaten livelihoods (Pettengell, 2010:3; NWPG, 2008:119; Scholtz, 2011:8). Global food production is compromised and quantifiable indicators suggest climate change could affect crop physiology and slow productivity (Lobell & Gourdji, 2012:1696). Climate risk also poses a threat to agriculture by accelerating soil erosion and degrading soils. This will cause lower yields and compromise food security (Lal *et al.*, 2011:276).

The Food and Agriculture Organisation (FAO) of the United Nations (UN) has attempted to quantify the impact of climate change by measuring trends in damages and losses in the agricultural sector. A post-disaster needs assessment based on assessments of 78 climate related disasters in 48 developing countries in Africa, Asia and Latin America from 2000-2013, amounted to total losses across all sectors of society measuring US$ 140 billion, while the agricultural sector lost US$ 30 billion (FAO, 2015:5). Losses in the face of changing climate seem inevitable, but of particular significance is that subsistence agricultural systems will be most severely impacted (Lal *et al.,* 2011:280). This is of concern because up to 75% of the world's poor live in rural areas, and most are involved in farming activities such as cropping and livestock, or forestry and aquaculture (Bleker, 2010:2). The FAO has called for increased investigation into the impact of climate change in the agricultural sector, since disasters resulting from

climate change and variability not only affect the production of crops, livestock and fisheries, but also destroy agricultural assets and infrastructure (O'Brien *et al.*, 2008:11).

The changes that have manifested have highlighted that present vulnerabilities, if left unmanaged, will lead to heightened vulnerability, since the likelihood exists that recovery times between disaster events will be shorter and thus the impact of each event on these communities will be greater (Wisner *et al.*, 2012:210). A 'business as usual' approach will neither stabilise food security nor secure a sustainable environment (Stern, 2006:35,143).

### 2.2.2 An African Perspective

The African continent is most vulnerable to climate change and variability (O'Brien *et al.,* 2008:10; Scholtz, 2011:11); vulnerable communities will thus experience increasing hardships. A land tenure system is prevalent across Africa which makes tenants "little more than temporary custodians of the land" and no individual holds exclusive rights to land (Tau, 2003:3). The argument against this system holds that communal ownership leads to "the commons syndrome" and a tendency to abuse rather than nurture the natural resources at their disposal (Tau, 2003:5).

According to Scholtz (2011:11), by 2020 climate change will have impacted the lives and livelihoods of up to 250 million people in Africa. It will result in increased pressure on water resources, lowered crop production, and compromised livelihoods and food security, and will likely be accompanied by the spread of vector- and water-borne diseases (IPCC, 2014:69). Water supplies and quality will both be affected and this is already negatively impacting the ecosystem (Vogel *et al.*, 2013:24; Schulze, 2005:99). By 2007 about 25% of the population (200 million people) were already subjected to water stress, but this is projected to rise to between 350 million and 600 million people by the 2050s (IPCC, 2007:435).

Changes already observed reflect an increase in variability of rainfall and temperature, and this will intensify further (Speranza, 2010:2). The impact of extreme events is likely to be felt even more severely than the impact of changes in mean temperatures (Morton, 2007:19684). Climate-induced extreme weather phenomena such as heat

waves, droughts, floods and cyclones have highlighted the vulnerability of both human- and eco-systems (IPCC, 2014:53). Increases in such extreme events will influence farming activities negatively, since crops will not only be vulnerable to the varied impacts of climate change, but they could also be damaged during the growing season by heavy rainstorms and flooding. They could also be subjected to prolonged heat waves and extended periods of drought. Regional studies in Africa have found that yields of maize in smallholder rain-fed systems in Africa are likely to be variable, but could decrease by as much as 10% by 2055 (Morton, 2007:19682). Even moderate temperature increases of 1°C - 2°C will negatively impact crop yields (Morton, 2007:19683). It is suggested that thermal stress will result in low conception rates, low productivity and a generally poorer condition of livestock. Increased risk of pests and diseases are predicted if temperatures rise and changed rainfall patterns might mean that livestock are exposed to new diseases (Morton, 2007:19683). Changes in ecosystems and shifts in species and habitats are already evident and occurring faster than originally predicted. The arid and semi-arid regions of the continent are expected to increase by up to 8% and many species of animals will be endangered because changes in the extensive grasslands will be significant (IPCC, 2007:435).

The underlying poverty throughout rural Africa contributes to vulnerability and poor adaptive capacity (Speranza, 2010:16). Climate change will effect repercussions in an agricultural sector already struggling with competition for land and natural resources to feed its people, let alone the anticipated population of 9 billion by 2050 (Bleker, 2010:1). Climate risk in the absence of adaptation is potentially devastating. Disaster risk requires action, but climate change adaptation (CCA) strategies for Africa need to be designed together with development initiatives and poverty reduction strategies in the region. Effective development can go a long way towards equipping developing countries to manage change better (Stern, 2006:92,99). There is a growing call for scientists and the disaster risk reduction community to address the risks in close collaboration with local knowledge networks. Climate change communication must be made more readily available and easy to understand by even the most vulnerable people (O'Brien *et al.*, 2008:21).

### 2.2.3 A South African Perspective

South Africa has an abundance of natural heritage, with some regions carrying a wealth and diversity of rare species (Ziervogel *et al.*, 2014:607), but it is also a semi-arid country with 14% of its surface area potentially arable (DEA, 2011:91). Primary agriculture contributes 3.7% to the country's gross domestic product (GDP), while agricultural workers make up 7.5% of the country's formal employment. About 50 000 large commercial farmers and 240 000 small farmers provide for their dependents and offer employment to another 500 000 individuals, while an additional three million farmers produce food for their own households (Oladele, 2011:92). Access to land is diverse in nature. While some farmers own or rent their land, South Africa has many farmers who have access to communal land (Tau, 2003:2). Another form of access is through different land tenure systems. In these instances the farmers have informal rights to use land but do not hold the title deeds. Many farmers are frustrated by this because they cannot use the land as collateral to access finance nor can they risk investing in the land (Tau, 2003:86,88). Any change in the 'drivers' in this fragile sector could significantly impact production, employment opportunities and foreign earning potential.

Water is considered "the primary medium through which climate change impacts will be felt by people, ecosystems and economies" (Stuart-Hill *et al.*, 2012:1). South Africa's Department of Water Affairs (DWA) has warned that the impact of climate change on water supply varies, with changes in rainfall predicted with respect to the magnitude, variability and extreme nature of events. Natural vegetation will change as climatic zones shift (Scholtz, 2011:17,18) and the effect will be a shift in patterns of land use, with changes in crop type e.g. farmers will plant sunflowers instead of the staple food maize (DEA, 2015a:67).

South Africa has been getting hotter and drier over the past four decades, with a marked increase in mean annual temperatures and in the occurrence of extreme rainfall events (Ziervogel *et al.*, 2014:605). From 1960 to 2010 climate trends saw mean annual temperatures increase by at least 1.5 times the observed global average; and maximum and minimum daily temperatures have steadily increased every year and in almost all the seasons. The annual rainfall trends reflect a general decrease in the number of rain days, an increase in intensity of rainfall and more prolonged dry spells (DEA, 2013:3).

South Africa's average rainfall of 450mm/year is significantly lower than the global average of 860mm (Benhin, 2008:666). Predictions for the next 50 years are that climate change will result in lower rainfall, especially in the western parts of South Africa and higher temperatures particularly in the interior, with increased flooding and drought events. Changes in the distribution and availability of water will change patterns in agriculture and more floods and droughts are likely to occur (DEA, 2006:5).

Rainfall patterns are particularly important since many hectares are under dryland production. Farmers rely on their knowledge of rainfall patterns and temperature norms, and planting times are scheduled according to the temperature and heat unit requirements of the crops. Changes in rainfall and temperature will therefore have serious ramifications for crop production (Schulze, 2007:1-2). South Africa is a primary grain producer in the region, with maize being one of the main staple foods. A compromised food supply will have far-reaching consequences (Benhin, 2008:667). Livestock production is another primary agricultural enterprise and the extensive grassland utilised by both formal and informal livestock sectors will experience increased pressure (DEA, 2015a:8,26,42). Careful management will be important because South Africa's marginal rangelands are already threatened by overgrazing, desertification, bush encroachment and climate variability (DEA, 2011:94). It was already acknowledged in the 2006 State of the Environment Report that "the general state of biodiversity and ecosystem functioning is not good" citing that about 50% of South Africa's wetlands had been destroyed, effluent pollution was growing causing a decline in the health of river systems, and there was widespread land degradation and a rapid spread of invader plant species. These were already placing increasing pressure on rural livelihoods and affecting production levels. That report concluded the human pressure on ecosystems was increasing especially in areas of high biodiversity and the result was over-exploitation and a subsequent decline in available natural resources (DEA, 2006:11,12).

Climate change certainly poses a threat and much of South Africa's water sources and food production systems are facing challenges since ecosystems and biodiversity is also changing (Ziervogel *et al.*, 2014:606). The Long Term Adaptation Scenarios (LTAS) project suggests that the zone in which this study was conducted in the NWP will likely face temperature increases of up to 2.5°C by 2035 and 3°C - 5.5°C by 2080-

2100, while rainfall will show a pattern of drying (DEA, 2013:121). Thus the dry regions in the west of the country are projected to become dryer still, which means that the impact on agriculture in the NWP is likely to be greater than elsewhere (BFAP, 2007:27).

### 2.2.4 North West province: An Agricultural Perspective

In this section the impact of climate change in the Mooifontein region is examined. Detailed attention is paid to the nature of farming in this region and to the circumstances and characteristics of the farmers.

About 3.9 million people populate the NWP and about 64 000 of those (1.7% of the population of NWP) are working in the agricultural sector (Jacobs *et al.,* 2009:1). Agriculture is integral to the economic development of the NWP and plays an important role in poverty alleviation. As with the rest of South Africa, land redistribution projects have been a factor in the NMMDM. The vision was that this would result in improved livelihoods, job creation, sustainable farming enterprises and household food security (NWPG, 2014:14). However, this has not been the case and the projects have been found to have low success rates (Antwi, 2011:iv). Of the 11.6 million hectares that constitute the NWP, 9.6 million hectares (81.1%) are agricultural land with 34.9% arable and 56% veld (NWPG, 2008:237). The land tenure programme is a common route to access land but it is also a source of much frustration and possibly contributes to the low productivity in the region. According to Tau (2003:99-100) there is an urgent need for the state to address land ownership issues and tenure reform in communal areas to improve production and farmer morale. With 43% of the province said to be “arable”, the NWP is considered an important contributor to the national “food basket” (DEA, 2015a:63). It is a semi-arid region that experiences mainly summer rainfall with an average of 360mm per annum. The rainfall is also erratic and is accompanied by high summer temperatures and high evaporation. Soils are sandy and vulnerable to water and wind erosion (Bachtiar *et al.*, 2003:xv). Botai *et al.,* (2016:20) conducted a study on the characteristics of drought and found that the NWP had been declared a drought disaster areas by the government since this posed a threat to food security. Their comparative analysis of drought indicators found that while droughts were more frequent in the Free State province, the droughts in the NWP during 1985-2015 were more intense. Agricultural activities in the Mooifontein region are primarily focused on

animal husbandry, raising poultry, and the cultivation of maize and sunflower crops. Most animals run on communal grazing lands that are not well managed (NWPG, 2013:129). The main biomes in the NWP are savannah and grassland (NWPG, 2014:2). These are sensitive to extreme temperatures and rainfall variability (NWPG, 2014:38). Data collected in 2010 on land cover in the NWP has shown that 55.6% of the land surface is undeveloped and 10.2% is degraded and abandoned so that it now seems natural and the little grassland that remains has very little protection (NWPG, 2014:16,39). The fertility level of cattle in these communal farming systems is low, which could be due to poor bull fertility, the low nutritional levels of the breeding cows, compromised genetics or the environment. This would likely be exacerbated by the poor natural resources and high levels of tick infestation (Mokantla *et al.,* 2004:34). The Mooifontein region does not have adequate water supplies (Getchell *et al.*, 2002:179) and water is primarily sourced from boreholes, some of which have had to be drilled as deep as 100m (NMMDM, 2015:42).

A more in-depth understanding of the nature of the people farming the land in the Mooifontein region will be helpful to inform the design of effective knowledge transfer systems about development and adaptation strategies. It was found that 70% of the farmers in the NWP are smallholders (DEA, 2015a:63). Research conducted by Botlhoko and Oladele (2013:201) revealed that most farmers are older than 55 years. Farm sizes range from less than 50ha to about 250ha. A large percentage of the farmers still practise monoculture, a system in which the same crop is planted every year, rather than following a crop rotation plan. This increases disease and pest damage (Ncube *et al.*, 2011:1) and probably contributes to the low productivity in the region (Botlhoko & Oladele, 2013:202). Their findings showed that most farmers still rely on other sources of income such as social grants and employment off the farm. Common farming enterprises range from vegetables, poultry, piggeries and livestock to cropping (Botlhoko & Oladele, 2013:203). Education levels are diverse, ranging from 16% with no formal education to 28% with primary school education and 54% with some high school level education (Botlhoko & Oladele, 2013:202). This is significant for adaptation education, since it has been suggested that literate individuals are more likely to accept new innovations and contribute to more sustainable farming enterprises than illiterate farmers (Botlhoko & Oladele, 2013:202; WRC, 2013: 25). A study on raising livestock in the region (Getchell *et al.,* 2002:180) reported how an illiterate

farmer had relied on his children to read the instructions on veterinary medication labels and was administering a 2ml instead of a 20ml dose of a drench treatment. Jacobs *et al.,* (2009:44) also highlighted that the low skills level of the agricultural sector were "worrisome" and impacted income profiles. Of interest to DRR managers in the region is that the dissemination of information to farmers takes place predominantly via radio, with other sources being extension officers, television and newspapers (Botlhoko & Oladele, 2013:202).

Climate change risk holds threatening implications mainly for the environment, the ecosphere, biodiversity and the natural order, and will impact farmers and farming activities negatively. There are already signs that the seasons are different and the "planting window is shifting to a week or so later" (DEA, 2015a:67) Patterns of land use and land cover will change over time, which will threaten rangelands and grazing for livestock (NWPG, 2014:23,24). Areas where maize was traditionally planted will shift and maize growing potential will decline in the west (BFAP, 2007:27; NWPG, 2014:24). In another review it was suggested that even a 1% change in rainfall could impact maize production by 1% (DEA, 2015a:64). This study revealed that the decrease in maize production around Lichtenburg, a town 50km east of the Mooifontein region, would be significant. It suggested that maize production would most likely not be viable in the region in the future (DEA, 2015a:66). It is also significant that livestock farming is regarded as having a low to medium sensitivity to climate change (DEA, 2015a:64), although increases in temperatures are likely to heighten the risk of diseases in livestock (DEA, 2015a:66). Sustainable livelihoods will be directly affected, which will in turn affect the general socioeconomic status of diverse communities. These insights demand that priority be given to adaptive management practices and skills, and fresh approaches to addressing the uncertainty accompanying a changing climate and climate risk management (Vogel *et al.,* 2013:4).

The NWP has a well-developed agriculture-based economy, but farming capacity has been reduced and the land has degraded as a result of inappropriate land use (DEA, 2015a:63). All these factors make the agricultural sector vulnerable to climate change. CCA is thus particularly important for rural communities who rely on these natural resources for livelihood generation and food security and it must form part of a DRR strategy for the agricultural sector in the NWP.

## 2.3 DISASTER RISK REDUCTION AND CLIMATE CHANGE

Clearly not all disasters are climate based. Nonetheless, disaster risk reduction (DRR) and CCA have many common interfaces. Development programmes face growing challenges caused by climate change and in turn climate change can potentially amplify disaster risk (Kadzatsa, 2011:23). At the same time, DRR should be 'the first line of defence' against climate change (Kadzatsa, 2011:20). Both DRR and CCA target the reduction of risk and the impacts of shocks, and aim to build resilience. Climate change can be said to be a driver of disaster risk; therefore analysis of climate risk must form part of DRR interventions (Pettengell, 2010:33). DRR processes such as prevention, seeking to build the resilience levels of vulnerable communities and conscious efforts to establish links between stakeholders are equally essential in the successful design of CCA programmes. Mercer (2010:261) cautions that while climate change is a priority on the global development agenda, communities identify climate change as one of many factors increasing their vulnerability. It is thus necessary to approach climate change risk management together with other issues that increase community risk (Mercer, 2010:261). Engagement between stakeholders participating in DRR policy making needs to be activated across global platforms in both top-down and bottom-up chains of communication. Risk governance moves beyond the role of government and its responsibility to secure the safety of its people to include all stakeholders, including civil society, NGO's and other role players as well as vulnerable communities (Cadribo, 2011:7). Three key characteristics of risk lie at the nexus. These are: 1) identify the hazard; 2) analyse vulnerability in the context; and 3) analyse the coping capacity of communities and their supporting mechanisms (Van Niekerk, 2011:9,10). These elements were incorporated into the HFA 2005-2015 guidelines for the implementation of DRR and building resilience (ISDR, 2005:13), and have been entrenched in the Sendai Framework for DRR 2015-2030 with the call for a multi-hazard approach and risk-informed decision making (ISDR, 2005:10).

In the following section the terms "disaster management", "disaster risk management" and "disaster risk reduction" are examined.

### 2.3.1 A conceptual overview

Until the 1990s a pure disaster management (DM)-oriented focus prevailed, in which the typical phases in the lifecycle of a disaster were described as a random collection of relatively uncoordinated responses by different government departments and NGOs (Kohler *et al.,* 2004:15). DRR, by contrast, goes beyond the purely reactive DM approach to disaster events. It is complex, long term and visionary and, according to Becker (2009:3), strategies for reducing disaster losses are sought by identifying ways to reduce the risk of future disasters. A systems based approach seeks to obtain a holistic view by understanding risks and the interdependent influences of the risks in a particular system (Becker, 2009:4). Van Niekerk (2007:6) further argues that while DM and DRR are neither mutually exclusive, nor is the one a substitute for the other, the focus of any disaster study ought to be on inherent risk rather than on the actual phenomenon itself. DRR is thus a methodical process pursuing the design of, and implementing an integrated combination of, appropriate policies, strategies and practices aimed at pre-empting hazardous situations and strategically lowering vulnerabilities in social systems in order to attain sustainable development (Mercer, 2010:2). DRM is "the application of DRR" with a focus on identifying, assessing and seeking ways to reduce risks in pursuit of avoiding and limiting the negative impact of prevalent hazards on a community (Van Niekerk, 2007:4). It is multi-pronged and investigates geological, meteorological, environmental, technological and socio-political hazards that stand to threaten society (Twigg, 2004:2). The social context of the disaster is relevant and must be understood in order to enhance understanding of the implications of a hazard or disaster risk within a particular society (Van Niekerk, 2011:6,7).

The term 'disaster' as defined by Wisner *et al.,* (2012:30) refers to any situation that involves a natural hazard that causes damage in some form, in that it impacts lives, causing casualties and/or a disruption in terms of their capacity and livelihoods; or economic disruption in such a way that those affected are overwhelmed and unable to cope with the situation on their own or struggle to recover without external assistance. A 'livelihood' is the inherent and combined strengths of the natural, physical and social environment that enables an individual to make a living. The sustainability of that livelihood is directly related to the ability to cope with, respond to and recover from pressures that threaten that livelihood (Nyamwanza, 2012:62). The United Nations

platform, International Strategy for Disaster Reduction (ISDR) (2009:17), defines a hazard as “a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage”. It does not seem unreasonable to conclude that climate change risk is a hazard to the agricultural sector and a lack of action would threaten the sustainability of livelihoods.

Disaster Risk Management (DRM) must then manage the risks associated with climate change “to avoid, lessen or transfer the adverse effects of hazards (climate risk) through activities and measures for prevention, mitigation and preparedness” (ISDR, 2009:10). Sir Nicholas Stern (2006:450) insists that adaptation and mitigation are not alternatives and both strategies must be pursued. In the following sections the complementary strategies of mitigation and adaptation are examined.

### 2.3.2 Climate change mitigation

Mitigation is defined as “the lessening or limitation of the adverse impacts of hazards and related disasters” (ISDR, 2009:19) and is considered a key strategy for coping with climate change. It implies the curtailing of, or efforts to reduce, GHGs and other factors driving climate change (Vogel *et al.,* 2013:2). Mitigation against climate risk therefore involves and demands changes in production and consumption patterns (Kane, 2000:75). The Kyoto Protocol adopted in 1997 was an international agreement that saw signatories committing to targets for emission reduction and was in itself a mitigation strategy to reduce GHG emissions (Kane, 2000:76). Early efforts at managing climate change were focused primarily on mitigation measures to lessen or limit the adverse impacts of hazards. Projects to reduce exposure to risk such as engineering techniques and hazard-resistant construction projects were the main interventions (ISDR, 2009:19). South Africa’s investment in the mitigation of climate risk has been evidenced through its commitment to formulating climate policy (DEA, 2011:46). For example, through South African climate change research in which climate change trends are analysed and projections are modelled alongside impacts and adaptation options. The aim is to understand the cross-sectoral implications for water and food security, and formulate appropriate policies (DEA, 2013:12).

In standard DRR practice, a risk matrix approach to climate risk assessment will identify hazards and define the associated risks according to the degree of risk. Wisner *et al.,* (2012:18) identify the need to develop a framework, which helps provide a more holistic view of natural hazards, DRM and DRR, to organise facts as "a first step towards understanding that marshals, arranges and reminds one not to forget to ask certain questions". The Pressure and Release (PAR) Model (see Figures 2.1 & 2.2) explains risk as an equation where risk (R) is the result of vulnerability (V) and hazard (H) combined i.e. (R = V x H). For this particular discussion then, V = the unique characteristics of a community (ISDR, 2009:21) as well as its circumstances within the agricultural sector, while H = climate change and other inherent hazards.

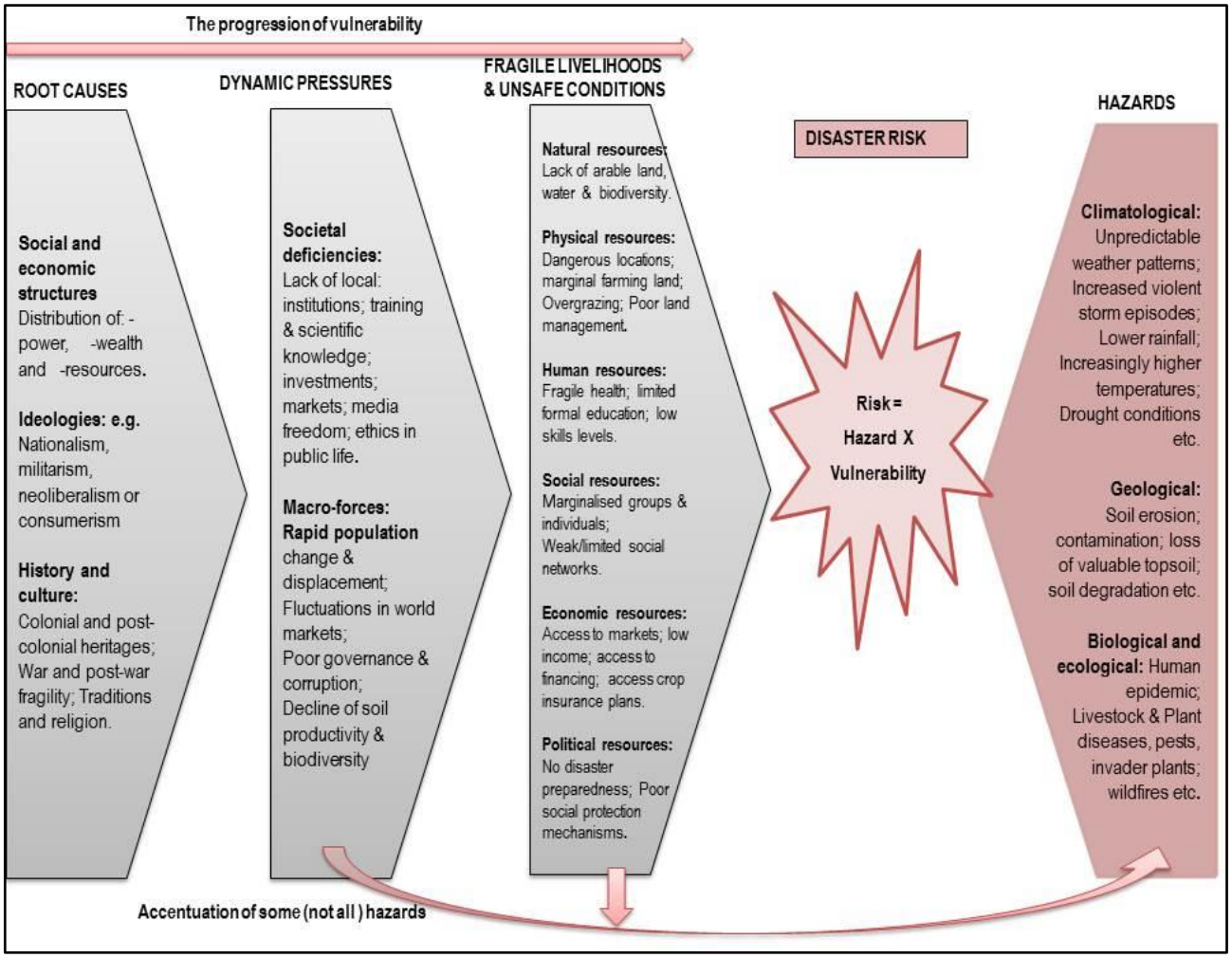


Figure 2.1: The Pressure and Release Model: The progression of vulnerability (adapted from Wisner *et al.*, 2012:23)

The PAR Model states that the point at which pressures from hazards and unsafe conditions collide is that point at which disasters will occur (Wisner *et al.,* 2012:22,25).

'Pressure' describes vulnerability, while 'Release' describes progression to safer living conditions according to human response:

1) The progression of vulnerability (see Figure 2.1): This process is triggered by *root causes* found in social and economic structures within which communities are framed including history, war, and local culture and tradition, alongside factors such as limited resources or underlying poverty. As a result of *dynamic pressures,* systemic societal weaknesses such as a lack of government action, support or scientific research into climate change and coping strategies, or macro processes such as changed rainfall and land use patterns, a decline in productivity or shifting climatic zones, the root causes translate into *fragile livelihoods and unsafe conditions*.

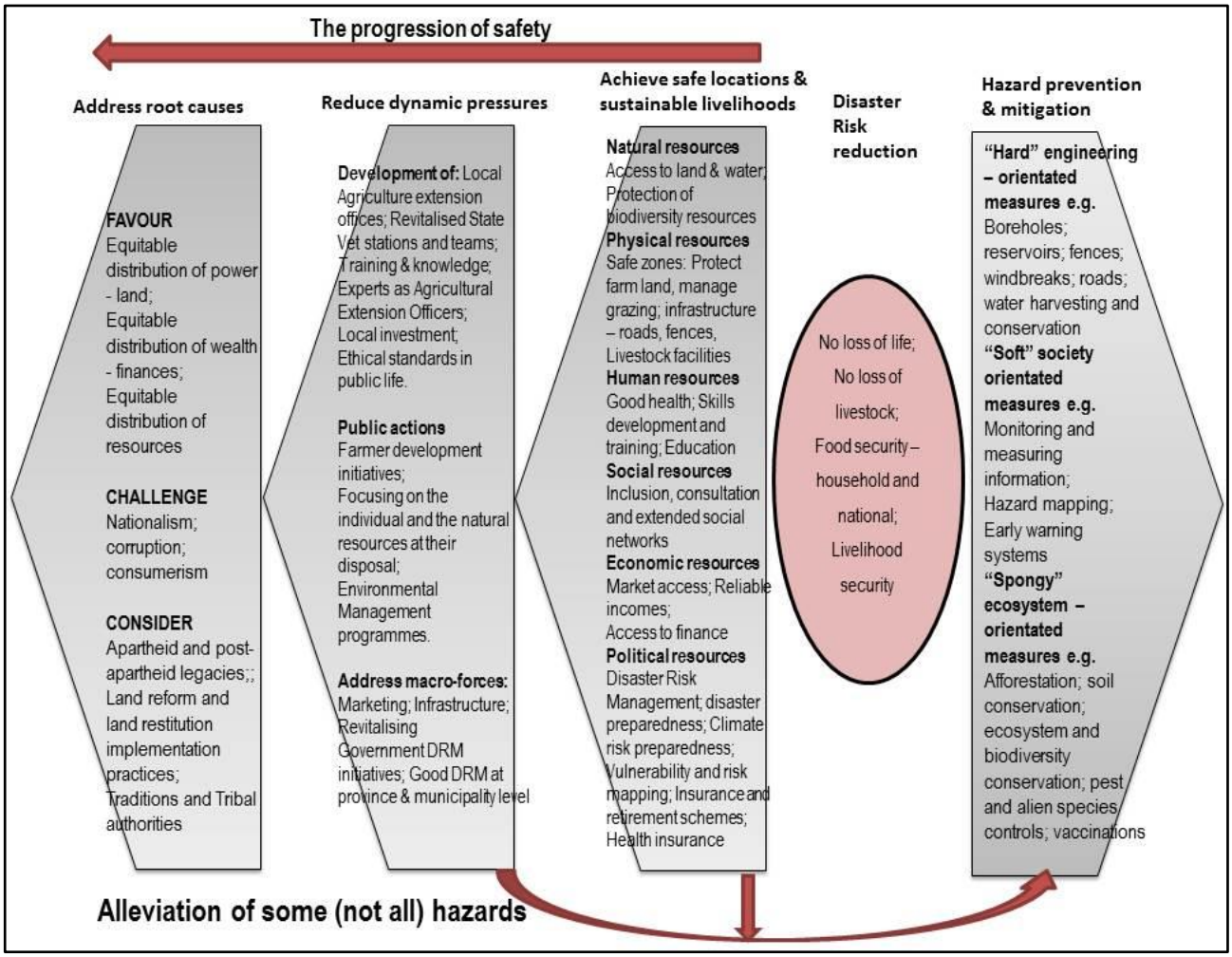


Figure 2.2: The Pressure and Release Model: The progression of safety (adapted from Wisner *et al.*, 2012:23)

2) The progression of safety (see Figure 2.2): describes an ideal progress towards more resilient livelihoods and safer conditions. This progress results from interventions that *address the root causes*, *reduce pressures* and *achieve safer conditions*. These preventive actions include *hazard prevention and mitigation,* but they also address the root causes of the vulnerabilities to reduce the dynamic pressures (Wisner *et al.,* 2012:31,32).

Vulnerability is that which leaves a community susceptible. A vulnerability approach examines root causes in socioeconomic, institutional, political and cultural spectrums of society, and determines resilience or coping capacity (Adger *et al.,* 2004:6). "Vulnerability is the function of the character, magnitude and rate of climate change and variation to which a system is exposed, and the sensitivity and adaptive capacity of that system" (IPCC, 2007:6). As far as climate change is concerned the concept of vulnerability has largely been described within the framework of a system's "marginality, susceptibility, adaptability, fragility and risk" (Leichenko & O'Brien, 2002:2). Within the agricultural sector, the farmer's levels of vulnerability go beyond normal regional, economic vulnerability or food insecurity to yield vulnerability. The ability to use early warning tools to anticipate poor climate conditions and plant accordingly, for example by using drought resistant seeds, further determines levels of vulnerability." (Leichenko & O'Brien, 2002:2).

Resilience is another facet of vulnerability and describes the ability of a community to bounce back or weather the storm through resisting, absorbing or accommodating the shock and then recovering and reorganising afterwards so that the restoration of basic structure and functionality is possible (ISDR, 2009:24; FAO, 2009b:18). Resilience is difficult to define (Frankenberger *et al.*, 2013:iii). It can be concrete and visible, such as purpose-built retaining walls or effective early warning systems, or it can be unseen, such as indigenous knowledge systems, education, skills or effective leadership. "Community assets, including social, human, financial, natural and political capital, are the tangible and intangible resources that enable communities" to meet their needs. A greater diversity generally suggests a greater capacity to respond to shocks to the system (Frankenberger *et al.*, 2013:11).

Society itself holds the key to successful self-preservation (Kane, 2000:76). There has been a shift away from snapshot-studies of climate risk to a people-orientated, socioeconomic view that assesses vulnerability as a region's capacity to cope, respond and adapt to climate risk alongside other risk factors such as HIV/AIDS, poverty and other stress factors that all add up to creating an environment of "combined exposure to double-risk factors" (Reid & Vogel, 2006:196). DRM takes a broader view of an "environment-society coupled system" (Smit & Wandel, 2006:28) that informs the design of cost-effective actions to reduce and mitigate the risks (Kabubi, 2011:54-55). Effective mitigation needs to be a cohesive design agreed upon between stakeholders and founded on international collaboration because "climate change has the characteristics of a collective action problem at a global scale". It is no longer an issue that can be addressed independently or remedied singlehandedly (IPCC, 2014:17). One approach to strengthening resilience is to consciously build it into policies, plans and programmes (ISDR, 2015:9), while another approach is to build on those strengths that already exist and are inherent within a community, the 'cultural resilience' of people and places (IPCC, 2014:26). The game changers in facing climate risk are the role players, the managers, from the highest level of authority to the lowest manager operating at grass roots levels (Lal *et al.,* 2011:276).

Links will always exist between mitigation and adaptation strategies (IPCC, 2014:17) and they will constantly influence one another, but effective climate risk management should employ both mitigation and adaptation approaches (Kane, 2000:76).

### 2.3.3 Climate change adaptation

Adaptation normally refers to a process or action within a social system with the specific intention of making adjustments in order to cope better and manage a stress factor, risk or hazard (Smit & Wandel, 2006:282; ISDR, 2009:4). Adaptation in the climate change context has been defined as adjustments that are made to both the natural and human systems as a response to actual or expected changing climatic conditions in an effort to limit damage or exploit opportunities (Kropp & Scholze, 2009:8). The term "adaptation" implies a course of action to build capacity and resilience in the face of risk and will include interventions in education, agriculture and healthcare sectors, as well as investment in infrastructure (Adger *et al.*, 2004:7).

Reid and Vogel (2006:197) note that adaptation has two faces: 1) it can be reactive and occur following a disastrous event, and then embrace the “build back better” philosophy of DRR (ISDR, 2015:14), or 2) it can be proactive by putting measures in place ahead of an anticipated disaster scenario. The argument for a proactive approach to the management of climate risk is that it builds resilience in a community and enhances its capacity to adapt. Many rural farmers with cropping and pastoral systems in marginal areas have already displayed this resilience, and have adapted by developing effective livelihood strategies that reduce overall vulnerability to climate shocks through various adaptive and coping strategies (Morton, 2007:19681). Adaptive activities include making use of biodiversity in cultivated crops and wild plants, increasing the integration of livestock into farming systems and diversifying livelihoods.

If adaptation is to make a contribution towards the improved wellbeing of current and future generations by securing livelihoods and maintaining healthy ecosystems, then it is imperative that development planners and policy makers understand that it is “place and context specific” (IPCC, 2014:19). Adaptation is no longer merely an overview of biophysical vulnerability, but also an investigation of social and economic forces that contribute to vulnerability and includes gender, age, disability or health, social standing and ethnic grouping as well as the broader context of national and regional policy frameworks. Adger *et al.*, (2004:30) clarify this as “social vulnerability”, which includes both the hazard and the potential consequence of a hazard event. Ziervogel *et al., (*2014:610) also recommend that vulnerability assessments, which begin at site or community level, take a wide-angled view on a country stressed across multiple sectors in order to best address the broad developmental objectives of the country.

Adaptive capacity can be increased, particularly if climate change impacts are taken into consideration where development planning is done, for example by incorporating adaptation and DRR measures in land-use planning and infrastructure design (IPCC, 2007:20). Nyamwanza (2012:64) suggests that livelihood resilience and adaptive capacity is a reflection of 1) the dynamics between the individual, a household and the community, rippling outwards and upwards to regional and national level; and 2) the sustainability or viability of the livelihood systems in a particular location. It is anticipated that multiple, interacting stress factors could be triggered that will be made worse owing to the presence of non-climate stressors present in the system, such as already

compromised human health, malaria, exposure to frequent droughts, degradation of water sources and extreme poverty (IPCC, 2007:48; Ziervogel *et al.*, 2014:606). Thus whereas climate change was once viewed as an environmental problem, current thinking recognises links between CCA, development and DRR (Lim *et al.*, 2004:14), and programme designers are encouraged to include adaptation into their development plans by identifying opportunities to build adaptive capacity (Lim *et al.*, 2004:20). Effectiveness is increased when links are established between climate change, social development and other sustainable development initiatives (IPCC, 2014:19,80).

Most adaptation programmes come at a price and the response to them is often dependent on the farmer's financial position, depth of knowledge and human resources. Research has shown that the lack of financial resources tends to be a greater problem for small-scale farmers rather than large-scale farmers. This includes access to credit, the cost of improved inputs and the cost of water management infrastructure (Vincent *et al.*, 2011:32). Transitioning to new farming systems can take time, and a period of low yields and profits could follow implementation. Thus it is the farmers themselves who pay the price for change, which they often cannot afford, so this is a barrier to adoption. This has prompted a call to link "climate finance" to climate change management (Lipper, 2014:6) and for greater financial commitment to support the adaptation processes (Lim *et al.*, 2004:168).

If changes in climate are affecting agricultural production, then all farmers, whether they are commercial, small-scale, emerging or subsistence farmers, increasingly have to manage their enterprises in changing conditions. According to Van Niekerk (2011:9), "we need to realise that we also have the capacity to make the right decisions, implement the right measures, and engage in intelligent development planning that will reduce the risk of disasters occurring". Climate-smart farming presents itself as one such opportunity.

## 2.4 CLIMATE-SMART AGRICULTURE

The term “climate-smart” was first coined by the FAO at the 2010 Global Conference on Agriculture, Food Security and Climate Change held in The Hague. Climate-smart Agriculture (CSA) (see Figure 2.3) is an agricultural system which increases productivity and sustainability, enhances resilience through adaptation and mitigates climate change through the removal or reduction of GHG emissions. This contrasts with conventional production systems, many of which are unsustainable and deplete the natural resources (Braimoh, 2012:36). CSA thus facilitates improved food security and creates an enabling environment in which development goals can be met (FAO, 2010: ii).

CSA is an integrated approach that requires the identification and implementation of sustainable agricultural development processes as a direct response to climate change (FAO, 2013a:ix). A CSA farming system is not a one-size-fits-all plan of action; it is rather uniquely designed for a specific location and combines policy, technology and financial processes in development planning for climate change risk management that incorporates CSA approaches (Lima, 2014:10). Each system thus needs to be formulated within a clear understanding of national and local policies, climatic conditions, capacities and cultural traditions. A CSA approach is intended to guide changes in agricultural systems in light of the need to sustainably address food security and climate change issues (FAO, 2013a:27). When summarising the conference, Chairman Bleker (2010:2) commented that Africa could benefit from CSA more than most “recognising the challenges posed by multiple global crises to the sustainable development prospects of Africa”. It is clear that traditional knowledge, although an important source of information, is no longer sufficient and further actions in the area of climate smart agriculture in Africa need to be promoted.

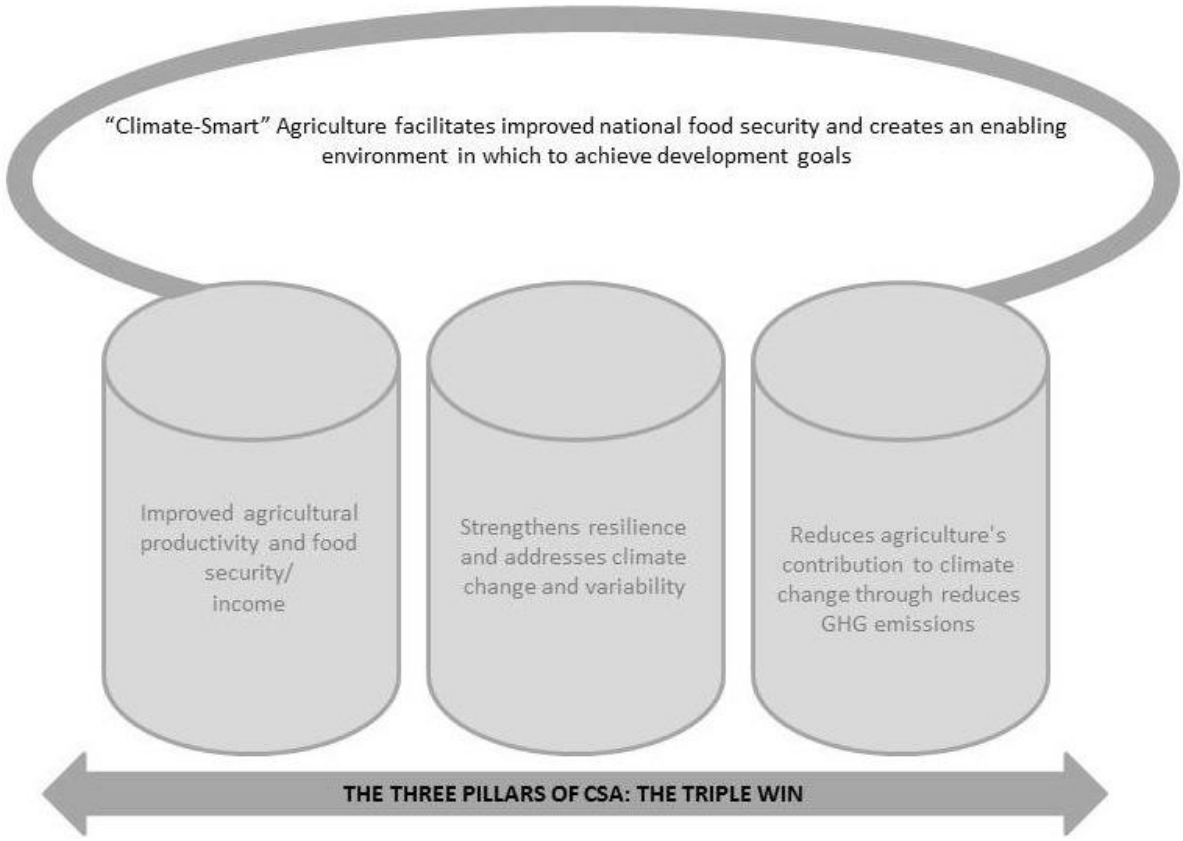


Figure 2.3: The key characteristics of "climate-smart" agriculture (Source: Adapted from FAO, 2010:ii).

Farmers accustomed to coping with uncertain weather patterns face unknowns with climate change (Lipper *et al.*, 2014:4), so training and capacity building are necessary to supplement local knowledge (FAO, 2009c:5,6). This has presented a challenge in sub-Saharan Africa, where limited material capacity and human resources are barriers to the implementation of CSA (Lima, 2014:29). The agricultural sector is increasingly turning to climate-smart farming for solutions. By way of example, Ugandan subsistence farmer Dorothy Musoke, once able to rely on familiar patterns of rainfall to plan her cropping, has found that *"the seasons keep changing; the rains don't come when I expect them, so then we have drought and it is so hard to grow anything"*. If her crops are not exposed to drought, they are damaged by rains that fall so heavily that the soil can't retain the water, and precious topsoil is washed away. Repeated crop failures have forced Dorothy to eat less and spend less, or fall back on short-term solutions such as loans or food aid. However with the assistance of an Oxfam project she is learning to adapt. She has dug a trench at the top of a sloping field to break the flow of

rain water so that it doesn't damage her crops, and she is also exploring the potential of other types of crops (Pettengell, 2010:8).

The challenges facing the sector, with a growing demand for food for a population predicted to increase by one-third by 2050, are significant. From 2010-2012 almost 870 million people were estimated to be undernourished, another billion were malnourished and 60% of those were food producers, smallholders and pastoralists (FAO, 2013a:5). CSA can enhance adaptive capacity by simultaneously contributing towards meeting national targets for food security and development, and offering farmers solutions to climate risk by providing them with a toolkit with which they can protect their livelihoods and build greater resilience into their enterprises. CSA's multi-pronged approach is a holistic, integrated one and needs to include stakeholders from all sectors of society in working together to structure DRR assessments, build policy frameworks and source climate finance towards effective implementation (Lipper *et al.*, 2014:4). The 3rd Global Science Conference on CSA held in France during 2015 noted that: 1) Agriculture must address the challenges of sustainable food systems and landscapes; 2) Researchers and practitioners must engage to build evidence and design pathways for multiple transformative transitions of CSA; and 3) The future relies upon policy, institutional and financing decisions (The Montpelier Statement, 2015:2,3).

### 2.4.1 CSA for sustainable food systems and landscapes

Improved water management is imperative since the anticipated higher temperatures and increased evaporation will impact the soil temperatures and available moisture levels (FAO, 2013a:111). Water harvesting, irrigation and the use of water resources must be secured and efficiency improved so that there is 'more crop per drop' (FAO, 2013a:84). Soil structure and health must be managed to improve productivity and reduce the need for synthetic fertilisers (FAO, 2013a:10). Systems such as CA, which use no-tillage, sustainable land management and agroforestry are climate-smart because they increase carbon content in the soils and aboveground biomass, and also enhance productivity and resilience (FAO, 2013a:50). Climate-smart cropping is premised on seeking to better understand biological farming methods and this includes the management of the ecosystem. Conservation and the sustainable use of genetic resources for food and agriculture must include biodiversity, while genetic diversity in crop varieties, livestock and even micro-organisms are fundamental to risk reduction

and the resilience of farm systems (FAO, 2013a:49). Livestock are significant contributors to food security and this sector will be acutely impacted with respect to water availability, grazing on veld and feed crops. Livestock health could also be threatened by shifts in the spread of pests and diseases. The management of grazing systems is therefore important (FAO, 2013a:216). Climate-smart fisheries and aquaculture support between 660-820 million people which is about 10-12% of the global population. This sector plays an increasingly important role in alleviating poverty and providing food security, but could become vulnerable with raised water temperatures and rising sea levels (FAO, 2013a:245). Harvesting, processing and supply chain management must be done in such a way that it ensures minimal losses and reduces wastage (FAO, 2013a:289,290).

### 2.4.2 CSA and DRR

Climate change jeopardises development assistance to poor communities consequently there is significant overlapping of goals between DRR and CCA, including CSA (Mitchell *et al.*, 2010:2; FAO, 2013a:360). CSA is, effectively, adaptation in action and is now a widely accepted DRR strategy (Lei *et al.,* 2014:1590; Mnkeni & Mutengwa, 2014:1; Lipper *et al.,* 2014:1,3*)*. Climate change mitigation and adaptation, and climate-smart crop production systems that ensure sustainability share common goals and work towards addressing climate hazards. Both processes aim to respond and adapt to changing climates by building resilience and practicing the sustainable management of natural resources (Scherr *et al.*, 2012:13). More effective and efficient DRR will positively assist the process of adaptation in the face of changing climate (FAO, 2013a:417) and CSA does this by discovering sustainable agricultural systems that provide food and nutritional security for communities through a process of integrated adaptation (Lipper *et al.*, 2014:3). Knowledge gaps must be identified and followed up with a process of knowledge transfer. However, good disaster risk governance will not only be a top-down exercise but will include all stakeholders in the process of developing policies and programmes (Cadribo, 2011:63). Inclusive capacity development is imperative since the implementation of CSA is based on expertise and knowledge but when planning DRR interventions communities most vulnerable to climate change must be taught to identify risks and be strengthened with coping skills (Kadzatsa, 2011:47).

### 2.4.3 CSA in action

South African farmers are well known for their proactive approach to new technologies. This opinion is supported by numerous examples of adaptive measures already implemented. Some farmers in the Western Cape have converted apple orchards into vineyards because grapes require less water and are more tolerant of high temperatures. In the Southern Cape other farmers have abandoned cropping and are planting pastures to enhance water storage capacity (Ziervogel *et al.*, 2014:611). The adaptable character of farmers was also mentioned in light of their readiness to adapt to new cultivars e.g. if a growing season is shorter due to late rains; or in making the decision to plant an alternative, quick-growing crop like sunflowers (DEA, 2015a:67). Minimum till and no-till soil preparation are important practices in a CSA approach, since the focus is on soil rehabilitation. The three key pillars to CA are: 1) minimal mechanical disturbance of the soil; 2) diversification through crop selection; and 3) building up a permanent organic soil cover through mulching. Farmers in Lesotho have increased yields by adopting CSA, known locally as *'likoti'*, by maintaining good mulch covering on the soil. This has increased soil fertility and reduced soil erosion. Lesotho's *'machobane'* farming system employs crop rotation, relay cropping and inter-cropping in a simple, cost-effective process that utilises organic fertilisers such as manure and ash, and increases year-round food security (Lima, 2014:14-15). New technologies and new cultivars can make the difference between food security and famine. A new drought-tolerant maize DroughtTEGO$^{TM}$ has been bred by the WEMA (Water Efficient Maize for Africa) project to give significant yield increases under drought stress and 'more crop per drop' (ARC, 2014). CSA practices encourage fastidious soil management, strict weed control programs and crop rotation (Du Toit, 2012:16). Healthy soils raise production potential while reducing GHG emissions, because less synthetic fertilisers need to be used (FAO, 2010:5). These have all been proven to build resilience and enhance coping capacity in the long term.

If CSA is an accepted and established tool for DRR within the context of climate change, then it is important that all stakeholders, including policy makers, scientists and development managers, should apply themselves to designing region-appropriate CSA strategies, as well as identifying appropriate methods for knowledge transfer to take place. The most important element of successful adaptation to climate-smart farming lies in the hearts of the farmers who need to make the changes (DEA, 2015a:69). For

this reason, the strategies employed in transferring knowledge and capacity building play a critical role in climate change DRR strategies.

## 2.5 ADAPTATION EDUCATION

Durand (2004:22) observed that knowledge was the main driver of pre-empting the negative impacts of climate change. Adaptation education is a critical element of any DRR process and should aim to address the two sides of the same coin. On the one side there needs to be discussion about the role every responsible individual needs to play to work towards decreasing the level of GHG emissions released into the atmosphere, and on the other side there is a need to adapt behaviour and practices to reduce the impact of climate risk on livelihoods. Adaptation education is the process whereby one strives to bridge the gap between knowledge and action (Cornell *et al.*, 2013:62). Professor H.J. Schellnhuber of the Potsdam Institute for Climate Impact Research believes the role of development experts is critical "since they work at a very important interface, they are multipliers of knowledge and therefore can prepare the ground for an accelerated transition to sustainability" (Kropp & Scholze, 2009:3).

The essence of a modern day approach to adaptation is its extensive, multi-sectoral scope. It is no longer accepted for experts to impose instructions or processes on a community that is told to follow "because it would be good for them". Instead it assumes a trans-disciplinary approach based on the collaborative efforts of scientists, civic society, government and the private sector, development NGOs and practitioners, and the everyman. This approach was also reinforced at the Southern African Adaptation Colloquium in 2013, at which the challenge was issued to both practitioners and scientists to use fresh approaches, move to a connected rather than a linear dialogue approach and to work *with* rather than *for* citizens (Vogel, 2013:6). When community members are included in a participatory learning process, in contrast to traditional technocratic, top-down interventions, there is greater willingness to create new knowledge, so transformation is likely to endure (Frankenberger, 2013:23).

Critical links must also be made between all forms of knowledge (Wisner *et al.,* 2012:593). Too often "old knowledge systems are still being deployed for these new

emerging social and environmental challenges" but they result in an ineffective transfer of knowledge and undeveloped capacities (Cornell, 2013:61). Too much of the knowledge produced stays trapped in silos and never facilitates real change that serves to make communities more resilient (Vogel *et al.*, 2007:352; Ziervogel, 2014:614). The challenges of achieving the successful adoption of climate-smart farming practices that build resilience and lower vulnerability requires a change in the way knowledge is gathered and dispensed in a process that has been termed a *'knowledge democracy'*, essentially an opening up of communication channels between the scientific community and regular society (Cornell, 2013:62).

During a vulnerability and adaptation assessment conducted in a community in the Muden valley of KwaZulu-Natal, farmers were asked for their opinions on climate change. The farmers claimed not to have observed significant changes in the climate over the previous five years, even though they agreed that water supply was reduced. There were simply many other more important issues that they saw as stressors challenging their farming and livelihoods (Reid & Vogel, 2006:203). The most effective adaptation in the face of climate challenge comes from making changes *'from the inside out'*; i.e. change is necessary first in the way people think about and perceive the problem even before any form of social or behavioural change can be implemented (O'Brien, 2013:2).

Grain SA manages a FDP that recognises that all development begins with the individual. Programme manager Jane McPherson (2011:email) believes that, while much is said about world food stocks and global food security, all food is still produced somewhere by someone and it does not matter if that individual operates on a large or small scale. The recognition of the individual farmer involved is fundamental to successful production. This is in line with the global trend that has seen farmers' organisations providing "demand-driven extension services" and promoting the adoption of CSA practices (FAO, 2013a:334).

Khapayi and Celliers (2016:37) have identified seven challenges facing emerging farmers, namely low education levels, lack of farming skills on crop and livestock production, poor management skills, high transportation costs, lack of market information, poor support services from the government and the fact that emerging

farmers tend to have less bargaining power when they market their produce. These represent barriers, not only to the successful commercialisation of emerging farmers, but also to an adaptation education process.

Communication is the key and dialogue must be encouraged. The primary focus of adaptation must be the point at which it will make a difference in people's lives within the local context (Stuart-Hill *et al.*, 2012:13). The ideal structure of an adaptation programme could be compared to a "bridge" or "highway" that connects policy and science with practice, but in reality the connectivity is far more complex and rather resembles entangled threads of chaos and confusion, more like "spider webs" (Vogel *et al.*, 2007:360). An analysis of five successful multi-stakeholder partnerships working towards common development goals found that each one had been grounded on a *solid organisational structure* and *driven by clearly defined objectives*. They also had a *specified timeline* and were led by *efficient project leaders* (Dodds, 2015:10).

Information, communication and knowledge are all elements of adaptation education for CSA. Key activities include local-level awareness raising, learning indigenous knowledge, training, discussions on best practices learnt, building and documenting local knowledge and establishing a best practice database, conducting demonstrations, facilitating capacity development and promoting official extension services. (FAO, 2013a:429). Questions need to be asked at local level such as what climate change trends can be identified locally; who is affected and how are they affected; how reliable is the information; are there options for adaptation and mitigation and finally, how the relevant information should be communicated to people (Kropp & Scholze, 2009:6). The knowledge that is produced on a platform shared by all stakeholders is said to be "socially robust knowledge" (Cornell, 2013:63). Participatory action research (PAR) serves to "bring local knowledge and capacities into the same arena as the formally-accepted knowledge of scientific researchers, policy makers and planners and to help establish a dialogue and co-production of 'hybrid' knowledge that combines local and outside specialist knowledge" (Wisner *et al.,* 2012:772). The result of this process is an informed community participating in the entire DRR process, from identifying hazards to seeking mitigation and adaptation solutions. Since they were contributors to the process and have developed a sense of ownership of the project, their active participation is more likely.

Adaptation education requires innovation and creative thinking. In responding to changes in the climate, the need for efficient agricultural advisory and extension services to provide region-appropriate services is greater than ever (FAO, 2013a:329). The technology that exists today offers many channels of communication for the dissemination of information (FAO, 2013a:328); as well as for social networks, discussion groups and transfer of knowledge. The new social platform provides new ways of constructing an *agora*, a meeting place or a market place, where the public can gather to discuss matters of concern. Cyberspace opens communication channels and presents opportunities for an exchange of knowledge (Cornell, 2013:63).

Modern day DRR practices follow a community-based approach, so climate risk DRR must follow standard DRR processes (FAO, 2013b:34) with a multi-sectoral effort across all levels of influence, from global and national to local interfaces. While the need for expertise from diverse disciplines and fields of knowledge is vital to the process, so too is the need for the wisdom inherent in ordinary people living in specific communities (Wisner *et al.,* 2012:1).

## 2.6 CONCLUSION

The aim of this chapter was to review literature on climate risk and the interface between DRR strategies and climate risk reduction. It was established that climate change had significant negative impacts on the natural resources critical to agriculture, as well as on the socioeconomic welfare of farmers, and this will continue into the future. The cost of climate change is already high and this trend is not likely to change. The literature reviewed has established that the rate of impact of climate change is more rapid than originally anticipated, which creates pressure on developmental initiatives to be effective. The literature further highlighted the current thinking of DRR, which is proactive and seeks to mitigate *and* adapt in the face of climate risk. A review of CSA confirmed the synergy with DRR. Further literature studies reviewed the participatory process with individuals and communities, and this revealed that successful adaptation embraces community participation. Another link was found between the literacy levels of community members and successful development, which highlights the need for partnerships with the communities so that adaptation strategies

will be embraced. Knowledge transfer plays a critical role and must be done using diverse mediums such as training and mentorship, the media and the written word.

In chapter three climate change management in the agricultural sector as it is currently entrenched in international and South African legislation and policy frameworks will be reviewed.

# CHAPTER THREE: A REVIEW OF PREVAILING POLICY FRAMEWORKS

## 3.1 INTRODUCTION

Chapter two comprised a review of the literature on climate change in the agricultural sector, with a particular focus on mitigation and adaptation in the face of climate change risks. The nature of farming activities in the Mooifontein region of the NWP and the role of climate-smart farming as a disaster risk reduction process were examined. International and national policymakers have played a significant role in the evolution, institutionalisation and implementation of DRM and climate change disaster management programmes, which has prompted a review of thought leadership and policy frameworks. In this chapter an attempt is made to understand the intention of policymakers regarding climate risk reduction, particularly in order to enable the researcher to benchmark field research findings against these. This review also examines climate change management in South Africa as it is currently entrenched in national legislation and policy frameworks.

## 3.2 DRM ON THE INTERNATIONAL STAGE

Awareness of environmental changes and rising levels of vulnerability to the increasing number of hazards grew steadily throughout the 1980s (UNFCCC, 2007:11). Simultaneously, DRR as a science and a coordinated commitment on an international platform was evolving and eventually formalised with the launch of the International Decade for Natural Disaster Reduction 1990-1999 (IDNDR). Commitments were made to actively reduce the consequences of natural disasters through planned interventions (ISDR, 2004:9). It was some time before the international community recognised the significant linkages between climate change risk and the negative impact on developmental goals but the United Nations Framework Convention on Climate Change

(UNFCCC) formally acknowledged that “climate change is fundamentally a sustainable development issue” (UNFCCC, 2007:7).

### 3.2.1 United Nations Framework Convention on Climate Change

The UNFCCC is an international treaty that was ratified and entered into force in 1994. The convention set out a basic framework of principles and commitments to climate change mitigation and adaptation. Its main objective was to stabilise GHG concentrations in the atmosphere within an appropriate timeframe to allow ecosystems to adapt naturally to climate change (UNFCCC, 2007). It also aimed to ensure the security of food production while enabling sustainable economic development (Scholtz, 2011:25). Schipper and Pelling (2006:29) have noted that the UNFCCC mandate refers only to climate change resulting from human activity and excludes the risks associated with climate variability. In 1997 the UNFCCC adopted the Kyoto Protocol which was aimed at enforcing the reduction of GHG emissions. Particular emphasis was placed on achieving a 5% reduction of GHG emissions in developed countries. Controversy arose concerning whether only developed countries should be held accountable for reducing emissions and this saw the United States reject the Kyoto Protocol in 2001 (Schipper & Pelling, 2006:33). The Kyoto Protocol eventually entered into force in 2005 but currently regulates only GHG emissions from developed countries (Schipper & Pelling, 2006:1). Beddington *et al.*, (2012a:1) have critically observed that, despite wide support for adaptation to and mitigation of climate change through an integrated approach in the agricultural sector, “financial and policy actions have been slow to materialise in most countries”, further suggesting that the UNFCCC was also too vague on these issues.

### 3.2.2 The Yokohama Strategy and Plan of Action for a Safer World

Disaster reduction was further entrenched by the adoption of The Yokohama Strategy and Plan of Action for a Safer World, which was formulated at a world conference on Natural Disaster Reduction, in Yokohama, 1994. The final report emphasised that it was a nation’s burden of responsibility “to protect its people, infrastructure and national, social or economic assets from the impact of natural disasters” (ISDR, 2004:9). The strategy highlighted socioeconomic vulnerability in disaster risk analysis and underlined the role of human action in reducing the vulnerability of societies to natural hazards. It also recognised the need to “develop and strengthen national capacities and capabilities”, including national legislation for disaster prevention, mitigation and

preparedness, as well as the “mobilisation of non-governmental organisations and participation of local communities” (IDNDR, 1994:5). The Yokohama Strategy for a Safer World was “a call to action, individually and in concert with other nations, to implement policies and goals” that might bring about a change in DRM (IDNDR, 1994:5). It is significant that at that point in time it was not yet considered necessary to highlight climate change as a natural hazard and nor was adaptation yet officially recognised as a DRR strategy. Climate change is not mentioned as a stress factor and driver of disaster risk anywhere in the report (IDNDR, 1994).

The year 2000 saw the UN General Assembly launch the International Strategy for Disaster Reduction (ISDR), which was intended to build on the work of the International Decade for Natural Disaster Reduction (IDNDR). Its mandate was to further promote public awareness and commitment to DR, expand networks and partnerships, and improve knowledge about disaster causes and options for risk reduction. Significant work was done to shift perceptions so that disaster reduction was not viewed only in the context of the hazards and their physical outcomes, but also in “physical and socioeconomic dimensions of vulnerability” thus ensuring the integration of DR into a much wider framework of sustainable development (ISDR, 2004:11).

### 3.2.3 The Millennium Development Goals (2000-2015)

The Millennium Declaration of September 2000 attracted the largest gathering of world leaders to commit to a global partnership towards poverty reduction by 2015. The Millennium Development Goals (MDGs) highlighted eight key objectives focused on streamlining initiatives to protect the vulnerable and the environment, namely:

1. Eradicate extreme poverty and hunger;
2. Achieve universal primary education;
3. Promote gender equality and empower women;
4. Reduce child mortality;
5. Improve maternal health;
6. Combat HIV/AIDS, malaria and other diseases;
7. Ensure environmental sustainability and
8. Develop a global partnership for development (UN, 2000).

By 2005 the United Nations Millennium Project (UNMP) had identified that increasingly frequent, extreme weather events and resultant disasters were an obstacle to the achievement of the MDGs. Predictions further suggested a rise in losses with extreme weather episodes taking their toll on lives and livelihoods (UNMP, 2005:181). It also highlighted the importance of integrating environmental objectives into sustainable development ambitions, since these two paths were inextricably linked (UNMP, 2005:1,263). Concern that pressures to concentrate on achieving the MDGs might lead role players to see disasters as an unrelated issue and therefore place more low key, and less newsworthy DRR issues low on the list of national governments priorities, were not unfounded. Experience showed that donors were more responsive to appeals in times of emergency after disaster events than to requests for assistance in pre-disaster event risk reduction (White *et al.*, 2004:4). Growing international understanding was leading the MDG community to the conclusion that disasters were retarding development programmes and progress towards achieving the MDGs; thus the call to pay increasing attention to DRR interventions (White *et al.*, 2004:9).

By the close of 2015, UN Secretary-General Ban Ki-Moon announced that the MDGs had effectively lifted more than a billion people out of extreme poverty, and had contributed significantly towards hunger alleviation and the sustainability of the planet (UN, 2015:3). However a final report on the MDGs states that a post-2015 development agenda must focus on environmental sustainability considering the challenges ahead, such as climate change, food insecurity and natural disasters (UN, 2015:61). The report further acknowledges that, despite gains made, vulnerable people are still marginalised and climate change and environmental degradation are definitely negatively impacting development progress (UN, 2015:8). The report identifies adaptation and mitigation of climate change as goals (UN, 2015:52).

### 3.2.4 Hyogo Framework for Action (2005-2015)

Recognition of the need to both mitigate and adapt to climate change, prepared the ground for the World Conference on Disaster Reduction held in January 2005. The Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters was adopted (ISDR, 2005). The fundamental principles of the HFA recognised that disaster prevention and preparedness:

- relied on effective planning and preparation at national and regional levels;
- required risk assessment for the design of appropriate measures and policies and for effective early warning systems to be put in place;
- are dependent on innovative thinking as well as innovation in the transfer of this knowledge to build a culture of safety and resilience;
- are dependent on the development and strengthening of capacities to prevent, reduce and mitigate disasters and inherent risk; and
- involved participation at all levels, from the local community through the national government to the regional and international level (ISDR, 2005:6,13).

Despite the fact that the HFA clearly recognised the need for DRR to be widely integrated into development policies and programmes, its fundamental flaw was that it was not a binding contract but a voluntary agreement (ISDR, 2005:18). This resulted in a lack of direction and much talk but little action, leading to the observation that "few of the governments" had made progress towards implementing that which had been agreed upon at Hyogo (Oxfam, 2009:2,3). Schipper and Pelling (2006:32) also suggest that the voluntary agreement status of the HFA 2005-2015, while holding significant status, did not evoke the same in terms of policy response to DRR and had "not led to the emergence of mechanisms with the same legal status as the UNFCCC."

### 3.2.5 Sendai Framework for Disaster Risk Reduction (2015-2030)

The HFA was followed by the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030, which was endorsed by the UN General Assembly in March 2015. It was a non-binding and voluntary agreement that included seven targets and four priorities for action (Kelman, 2015:117).

The Seven Global Targets were to:

1. Reduce global disaster mortality by 2030;
2. Reduce the number of peoples affected globally by 2030;
3. Reduce economic losses directly resulting from disasters;
4. Substantially reduce disaster damage to critical infrastructure and the disruption of basic services;
5. Increase the number of countries with national and local DRR strategies by 2020;

6. Increase international cooperation to developing countries by providing support that serves to complement national actions for the implementation of the Framework by 2030; and
7. Make early warning systems and DR information such as assessments more available and accessible to the people by 2030 (ISDR, 2015:12).

The Four Priorities for Action were:

- Understand disaster risk in all dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment so that the knowledge can be used in risk assessment, prevention, mitigation, preparedness and response strategies;
- Strengthen disaster risk governance and foster collaboration and partnerships at national regional and global levels to manage DR;
- Investment in DRR for resilience from public and private sectors to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment; and
- Increase and ensure capacity in disaster preparedness for effective response, incorporating “build back better” and DRR measures in the recovery, rehabilitation and reconstruction process (ISDR, 2015:14).

This framework reflects the evolution of DRR in that it is focused as much on the vulnerability and coping capacity of a community to anticipate, respond to and recover from the impact of a hazard as on the phenomenon of the hazard itself. It also recognised the need to move away from a silo mentality to integrated cross-sectoral cooperation and collaboration that extended across sectors such as agriculture, education and health, and linked national to regional and global partnerships. Some members of the DRR community have expressed their reservations about the new framework. Kelman (2015:117) believes that, overall, the SFDRR has placed too much emphasis on the hazard risk of climate change “rather than supporting an all-vulnerabilities and all-resiliences approach” to DRR. Oxfam also expressed its disappointment, suggesting that the framework was built “around a set of flimsy, unambitious targets that will not galvanise bold action or create meaningful accountability” (Oxfam, 2015).

### 3.2.6. Climate-smart agriculture on the international platform

Of particular relevance to this study is the multi-nation recognition that it is indeed in the national interest to encourage the adoption of CSA, since it promotes environmental sustainability and improves food security. There is widespread acceptance that policy frameworks must be structured to stimulate and support the process so that CSA is mainstreamed into core government policies and programmes (FAO, 2013a:357), and acknowledgement that governments must be willing to invest in the process in order to reap long-term benefits (FAO, 2013a:379). CSA is considered suitable even for the most vulnerable since it seeks to improve food security. However, those households that are least likely to be food secure are also those that are least likely to adopt new CSA practices. The challenge is to ensure inclusiveness and build 'safety nets' with resources of food or grant funds while enhancing adaptive capacity through skills development and assisting in the rehabilitation of depleted natural resources (FAO, 2013a:453,463).

## 3.3 DISASTER RISK MANAGEMENT IN SOUTH AFRICA

South Africa has been considered a leader in the field of disaster risk management since it signed a notably sophisticated disaster management plan into law. The encompassing framework was considered pivotal to evolved DRM thinking in that it presented a modern approach to disaster risk reduction by highlighting the importance of preventing and reducing the risk of disasters (Van Niekerk, 2014:858).

### 3.3.1 South Africa: Disaster Management Acts

A policy framework for DRM in South Africa was defined in the Disaster Management Act 57 of 2002 (South Africa, 2002). This entrenched a multi-sectoral and multi-disciplinary approach that is aimed at both the prevention and reduction of the risk of disasters; mitigates the severity and consequences of disasters; reinforces the value of emergency preparedness; promotes rapid and effective action in response to the occurrence of disastrous events and supports post-disaster recovery and rehabilitation efforts (Van Niekerk, 2007:6). The Disaster Management Amendment Act 16 of 2015 further stipulates actions towards risk reduction and includes the "conducting of disaster risk assessments" and "the mapping of risks, areas and communities that are

vulnerable to disasters". It further determines that national, provincial and disaster management advisory forums are to develop and communicate measures aimed at reducing the risk of disaster through instruments that facilitate the adaptation to climate change taking both the ecosystem and community-based adaptations into consideration (South Africa, 2015:3,12). Despite the comprehensive national framework, it seems to be common practice for the national government to leave the interpretation and implementation of the policies to provincial authorities and local municipal governments. What becomes clear from a review of provincial and municipal reports is that, despite pioneering national strategies, there continues to be a lack of focus, exacerbated by limited capacity of local government structures, to deal with climate change.

### 3.3.2 DRM and CCA in the Ngaka Modiri Molema District Municipality

A desktop search for information about DRM and CCA policies in the Mooifontein region which lies within the NMMDM has revealed a worrying lack of understanding of the looming crisis of climate change impacts. There appears to be little comprehension of the true nature of DRR and only token commitment to DRM and CCA policies. A review of the Annual Report for 2013-2014 for the NMMDM highlights the issues at regional level. The DM activities mentioned include measures to renovate a dilapidated building, the establishment of Disaster Management Consultative forums at local level, resuscitating a District Disaster Management Advisory forum and performing informal risk assessments. These were conducted in three communities in the year under review (NMMDM, 2014:80). Of the disasters listed for 2012-2013 (no records were provided for 2013-2014) 101 roofs were blown off in thunderstorms, 88 house fires, 10 fatalities, six collapsed structures, one flood incident, one blocked drain and one aircraft accident (NMMDM, 2014:76). The draft Integrated Development Plan, 2012-2016 for the Ngaka Modiri Molema District Municipality contains no reference to climate change or adaptation and the incorporated DM plan includes building a DM centre for the district and conducting 10 awareness campaigns about floods, veld fires, the handling of hazardous material, greening the environment and road accidents (NMMDM, 2012:59). The current attitude to DRM in the district is best summarised in the report, which notes that "some stakeholders do not take Disaster Management seriously… and there are no sufficient budgets made available for Disaster Management projects" (NMMDM, 2014:84).

The purpose of highlighting the DM activities in the above-mentioned reports from a regional platform is to support the view that, despite international agreements such as the HFA and the Millennium Declaration, and despite sophisticated national strategies and policies, provincial and local governments have not made sufficient progress in the implementation thereof. International thinking determines that risk management should be integral to organisational strategies and governments' policies, but there is often a lack of know-how and guidelines as to how this should be achieved (Twigg, 2004:22). Emergency and response processes will always form a necessary part of DM but more proactive investigation and planning is required in terms of building the body of knowledge on risk and understanding the impact of hazards on top of social, economic and environmental conditions. DRR policies and measures need to be implemented to build resilience to hazards in societies and to ensure that all the effort that is invested in development does not increase the levels of vulnerability to the hazards (Van Niekerk, 2007:7).

### 3.3.3 Climate-smart agriculture on the national DRM platform

Minister of Environmental Affairs Edna Molewa has acknowledged that the impacts of climate change will affect everyone, with the potential of very real and negative impacts on South Africa's development agenda (DEA, 2015b). The thrust of the South African argument at the 21st UNFCCC Conference (COP 21) in Paris in 2015 was nonetheless still focused on demanding fair participation in global efforts to lower GHG emissions, with developed countries taking the lead in global gas emission reduction so that developing countries might continue focusing on the challenges of necessary economic growth, job creation and poverty alleviation.

> *The DEA is proud of the "progressive, innovative and proactive policies and plans" that have been put in place. The principle of sustainable development is fundamental to Vision 2030 which is written into the National Development Plan (NDP).*
>
> *We have a National Strategy for Sustainable Development, a National Climate Change Response Policy, Green Economy Strategy, and an Integrated Resource Plan (IRP) – which outlines our country's energy mix. This is in addition to our Industrial Policy and Action Plan that recognises that*

> *energy efficiency and less-carbon intensive production are central tenets of a green economy. A National Adaptation Strategy is under development to guide South Africa's efforts to plan for and adapt to the impacts of climate change (DEA, 2015b).*

According to this draft National Adaptation Strategy, South Africa has seen progress on CCA at national, provincial and local levels. The "aspirational goal" is to build climate-resilience further and "institutional arrangements for CCA will facilitate coordinated implementation that optimises development outcomes, necessary transformation, and the interlinked needs of adaptation and mitigation imperatives" (DEA, 2016:vii). Van Niekerk (2015:408) notes that DRM Centres at national, provincial and municipal levels have been established with "good practices in horizontal and vertical stakeholder involvement" however the weak links appeared at local level as many local politicians had no understanding of the concept of DRR and that effectively hampered the work of institutional employees. It was further noted that the decision making processes were not inclusive and neither did they acknowledge indigenous knowledge systems.

There is no question that South Africa has an acute awareness of CSA, as well as a sophisticated policy framework for DRR, that are both in accord with stated international objectives. The challenge that remains is to effectively shift theory into practice. South Africa's policymakers and the academic fraternity have partnered effectively on issues of climate change, which resulted in the National Climate Change Response White Paper (Ziervogel *et al.*, 2014:606). It is, however, often the case that a great body of knowledge exists about climate change and adaptation, and that the policy frameworks that are in place are sound, but there is a major disconnect between the information, which remains trapped in policy documents and the corridors of power. The effective education of individuals' whose lives could be changed if resilience were to be built into them through knowledge and access to up-to-the-minute information services, is never prioritised and thus stays "left behind" and lost inside a forest of paperwork. Ziervogel *et al.*, (2014: 612) call these 'knowledge gaps' and maintain that a great deal of effort is required, in particular with 1) conducting adequate impacts assessments and quantifying the socioeconomic cost of climate change, and 2) the challenges experienced in finding effective ways in which the public and private sector might collaborate in order to meet the adaptation needs. The organisation Biowatch is a local

non-governmental organisation (NGO) that has expressed concern that CSA in South Africa is framed too broadly (Mnkeni & Mutengwa, 2014:3). Implementation at grassroots level has to happen if policy is to translate into meaningful sustainable development and CCA. Mnkeni and Mutengwa (2014:19) observe that despite the South African government's support and promotion of CSA, workshops need to be held to develop a common understanding with the participation of all stakeholders in order to facilitate a broader ownership of the policies. They hold the view that, despite considerable local knowledge about CSA, there is a lack of coordination between the research and information generated and the farmers who should be using the information. Another weak link in the knowledge transfer process is the extension officers, who need to be re-trained and equipped with knowledge about CSA practices (Mnkeni & Mutengwa, 2014:20). Montmasson-Clair and Zwane (2016:12) also hold that there is a missing link between national policy on CCA and the grassroots, and highlight the fact that some provinces have change response strategies in place but others, including the NWP, do not. Three key issues they highlight are limited capacity to implement change response, lack of dedicated budget for implementation and none or limited provincial institutional capacity for climate change response implementation (Montmasson-Clair & Zwane, 2016:13). Change needs to happen at the heart of local government and "local government should aim to involve all people, especially vulnerable and marginalised groups, in disaster risk reduction and/or prevention". It is the responsibility of local governments "to provide the necessary structures and support" (Botha & Van Niekerk, 2013:9,10) in the application of DRR and associated concepts such as CCA and CSA, but such mechanisms are missing (Van Niekerk, 2015:409).

### 3.3.4 The challenge of knowledge transfer in an African context

Some challenges to understanding climate science in Africa are knowledge gaps that have arisen due to a lack of observation and data, weak leadership or funding and capacity constraints.

It is important that all stakeholders and role players understand the full scale of the challenges facing climate change information and adaptation processes in Africa. Jones *et al.,* (2013:1) have observed that there are a number of factors that affect our understanding and suggest that if barriers are to be overcome we need to recognise the

existence of both knowledge gaps and capacity gaps, which need to be bridged. Not only is knowledge of climate limited across Africa, but there is also little capacity to conduct climate modelling or interpret and apply the collected data. The inability to access data is a serious constraint, either as a consequence of natural disaster or conflict in war-torn nations, but there has also been reluctance on the part of African meteorological agencies to make their data available (Jones *et al.,* 2013:5).

Challenges that need to be confronted include knowledge generation and the ability to communicate the information in a relevant way, because "messages are often contradictory and unsuitable for informing adaptation" (Jones *et al.*, 2013:2). The challenge is further enhanced by a lack of co-operation and collaboration between climate scientists, decision makers and practitioners. This influences policy makers and their ability to make accurately-informed decisions (Jones *et al.*, 2013:3). This view is supported by the African Climate Development Programme, which observes that "climate services in Africa are not well developed" and highlights the limits to the understanding of the climate systems on the continent, particularly due to extreme variability in the different regions (ACPC, 2013:1). This is exacerbated by a disconnect between the national development agendas of nations and their National Meteorological and Hydrological Services (NMHS), as well as a lack of insight by the NMHSs of user needs and an inability to present significant or useful information (ACPC, 2013:2). Climate change information is relevant only if it can be understood in practical terms regarding how communities are affected, for example through food production and security, availability and quality of water resources and general wellbeing.

African governments need to urgently address these issues if CCA is going to be effectively mitigated and adapted to at grassroots level. There needs to be more investment in the capacity building of scientists and researchers so that they are able to translate the relevant information and communicate it effectively. This is necessary so that policymakers will understand the threat of climate change for their people and be more inclined to mainstream climate and adaptation issues into normal development planning frameworks. A case in point is that of the eThekwini Municipality, Durban.

Dr Debra Roberts, head of the Environmental Management Department in eThekwini, wanted to ensure the prioritisation of environmental issues, including climate change

and adaptation. Despite the fact that, on the face of things, the municipal government had developed a sophisticated climate change strategy, it was not until climate change issues were "rooted in local realities" that any real impetus to climate change related-work was experienced (Roberts, 2008:521). Roberts identified processes that could lead to the mainstreaming of climate change. These effectively translated scientific models and data into easily understood, practical information about the implications of climate change for the local experience. She also created awareness of the likely impacts on infrastructure, human health, food security and agriculture, water, tourism/business and biodiversity (Roberts, 2008:529). This highlights the value of intervention and knowledge sharing at community level, since a real understanding provoked enthusiasm and commitment to CCA and DRR. In addition, this case study shows the potential for bottom-up pressure that motivates policymakers and institutions to spring into action (Roberts, 2008:536).

## 3.4 CONCLUSION

DRM has changed since the 1970's, when disasters were viewed either as "an act of God" or "an act of nature" (Wisner *et al.,* 2012:xxx). Increasing cooperation between stakeholders is critical for successful sustainable livelihood development and DRR. The SFDRR affirmed international commitment to a proactive DRR pathway of building disaster resilience. History has revealed that many challenges are faced not only in actual implementation of development and adaptation programmes at grassroots level, but equally in coordinating the work, thought leadership and agendas of many diverse role-players, from scientists to funders, development organisations and national governments. Manyena (2016:46) insists that the real challenge going forward is the "fragmentation" that persists despite overwhelming consensus that DRR and CCA are essential to sustainable development. Holloway (2007:1) has reflected on the "lack-lustre" progress following the promulgation of South Africa's Disaster Management Act, 2002. The move had suggested a commitment by policymakers to a new era of DRM in South Africa. In practice, enormous challenges were faced in institutionalising the law and filtering it down to provincial and regional administrations for meaningful DRM. Another challenge has been managing the removal of traditional boundaries between institutional silos, accustomed to functioning as autonomous entities. There were now a

multitude of stakeholders with whom they had never previously had to interact but which they now needed to engage and this required networking across multi-disciplinary fields (Holloway, 2007:6). This is not impossible because it has been seen in the example of the successful shift in thinking at the eThekwini Municipality, Durban, which merely required commitment to translating science into meaningful information. The same challenge faces DRM practitioners in the agricultural sector, since most farmers rely on extension workers to deliver critical information to them (Oladele, 2011:93). Regional policymakers and local extension officers must be equipped with insights about the relevance of climate change risk to their own lives and in this way might unlock enthusiasm for significant and transforming CCA and DRR processes. The field of DRM is an “intellectually exacting and dynamic arena, underpinned by a historically entrenched commitment to humanity” (Holloway, 2007:8). The challenge that still remains in South African is to translate the Disaster Risk Management Act into practices that improve the lives of people who are coping with changing conditions on a daily basis.

# CHAPTER FOUR: FINDINGS AND ANALYSIS

## 4.1 INTRODUCTION

The aim of chapter two was to investigate the influence of climate change on the agricultural sector. It was found that climate change was already influencing agriculture already and would have a greater impact in the future. Thus a path of adaptation was essential to increase resilience and ensure sustainable production. Furthermore, the natural synergies between the theoretical approaches of DRR and climate change mitigation and adaptation were substantiated. The concept of "climate-smart agriculture" was also investigated in chapter two, and it was verified that both benefits such as soil health and moisture conservation, and challenges such as cost implications and a lack of knowledge, accompanied the introduction of climate-smart farming systems. The objective of chapter three was to investigate international policy frameworks and South Africa's DRR framework and climate change policy. The literature review indicated that progressive international DRM and climate change policy frameworks existed and that DRR in South Africa was entrenched in an enlightened legislative framework. Poor implementation processes, however, were said to result in little effective transformation.

The research objective was to analyse climate change and impacts in the agricultural sector in the Mooifontein region. Thus the next aim was to acquire insight into agrarian-based lives and livelihoods. The empirical findings of the consequent inquiry are outlined in this chapter. These include reports from observations of photographs and rainfall data, and analysis of the responses of local farmers and agricultural experts to the research questions.

## 4.2 THE QUALITATIVE RESEARCH APPROACH EXPERIENCE

The research approach to this qualitative inquiry, which followed a phenomenological design with an inductive, open-ended strategy, was discussed at length in chapter one (see Chapter 1.7). A brief discussion of the researcher's experience of the qualitative research approach follows.

The researcher's preferred use of the phenomenological method was chosen to examine reality as a phenomenon, without any trappings of elaborate academic jargon, by going "back to the things themselves" (Groenewald, 2004:43). This meant it was possible to explore the reality of "insiders" (De Vos *et al.,* 2011:308) and encouraged participants to share their own "lived-world" experiences (Groenewald, 2004:43). These encounters helped the researcher to gain glimpses into the world of the participants (Struwig & Stead, 2001:15), while the semi-structured nature of the interviews enabled the flexibility afforded by a qualitative research design (Hoepfl, 1997:52). The researcher acted as an unbiased "human instrument of data collection" (Hoepfl, 1997:49) to learn about the participants' experience of the phenomena under inquiry (Hoepfl, 1997:49).

Triangulation was implemented using a three-tiered approach to confirm the accuracy of key findings (Creswell & Miller, 2000:126; Cho & Trent, 2006:323) namely: 1) researcher observations in the region collected from rainfall records (see Appendix C), photographs, and diary entries (see Appendix D); 2) semi-structured interviews investigated farmer perceptions of climate change and climate-smart farming (see Appendix A), and 3) semi-structured interviews with a selected group of agricultural specialists to learn about best practice and CCA farming systems in the Mooifontein region (see Appendix B). Member checking is another process of validation that reassures the reader that the participants are satisfied that the findings are truly representative (Cho & Trent, 2006:328). Although it was not possible to see every participant again, there was sufficient follow-up with some participants to say that member checks were conducted. Finally, since good research is supported by thick, rich description, this study has attempted to peel through layers of insights into the lives, emotions and circumstances of the farmers with the aim of contextualising the

place and people to be able to provide as much detail as possible for the reader (Creswell & Miller, 2000:128).

Creswell and Miller (2000:127) suggest that researchers should "self-disclose their assumptions, beliefs and biases". In this case, the researcher was a farmer who had already been involved in the agricultural lobby and farmer development support for 16 years. After having been exposed to specific sectoral studies on the impacts of climate change, and the need for adaptation and mitigation (Van Zyl, 2006; Vogel, 2008), the seeds were sown for further enquiry into the challenges facing farmers at grassroots level. This urge agrees with the insight of De Vos *et al.*, (2011:49) that when one theorises inductively, one begins with "an observation".

Empirical research entails going to the field of study. The researcher was able to do this over a period of three years for the purposes of general observation and contact with the farmers and agricultural experts. The observations made over this time were invaluable and have added richness to the study. The findings and analysis are discussed in the next section.

## 4.3 RESULTS AND ANALYSIS

This section is comprised of 1) non-participant observations; 2) analysis of the discussions held with farmers and 3) analysis of the discussions held with the agricultural experts, based on the semi-structured interview guides for each group of participants. The first discussion is based on researcher observation and findings.

### 4.3.1 Non-participant observations and findings

The theory of climate change is that unpredictable and erratic rainfall patterns and shifts in seasons are impacting livelihoods (Pettengell, 2010:3; NWPG, 2008:119; Scholtz, 2011:8). According to Vogel (2008), it is imperative that adaptation principles and best practice agriculture for climate risk reduction be taught to farmers wherever development activities occur in order to build the resilience of their farming communities (Vogel, 2008). This view prompted a review of the South African Weather Services' (SAWS) rainfall data for the Mooifontein region recorded at Lichtenburg Silverton

[0471259 1] station (SAWS, 2016). The total annual rainfall record from July 1929 to September 2016 (see Appendix C) reflects cycles of high and low rainfall, with an annual average rainfall of 515.5 mm. In spite of the apparent consistent cyclical nature of the graph, a slowly decreasing trendline of the annual total can be detected sliding from just below 600mm/ year in 1929 to 450mm/ year by 2016. The accumulated monthly rainfall pattern from 2010 to 2016 is shown in Figure 4.1. It is clear that from 2012 to 2016 the rainfall has been consistently below average in almost every month.

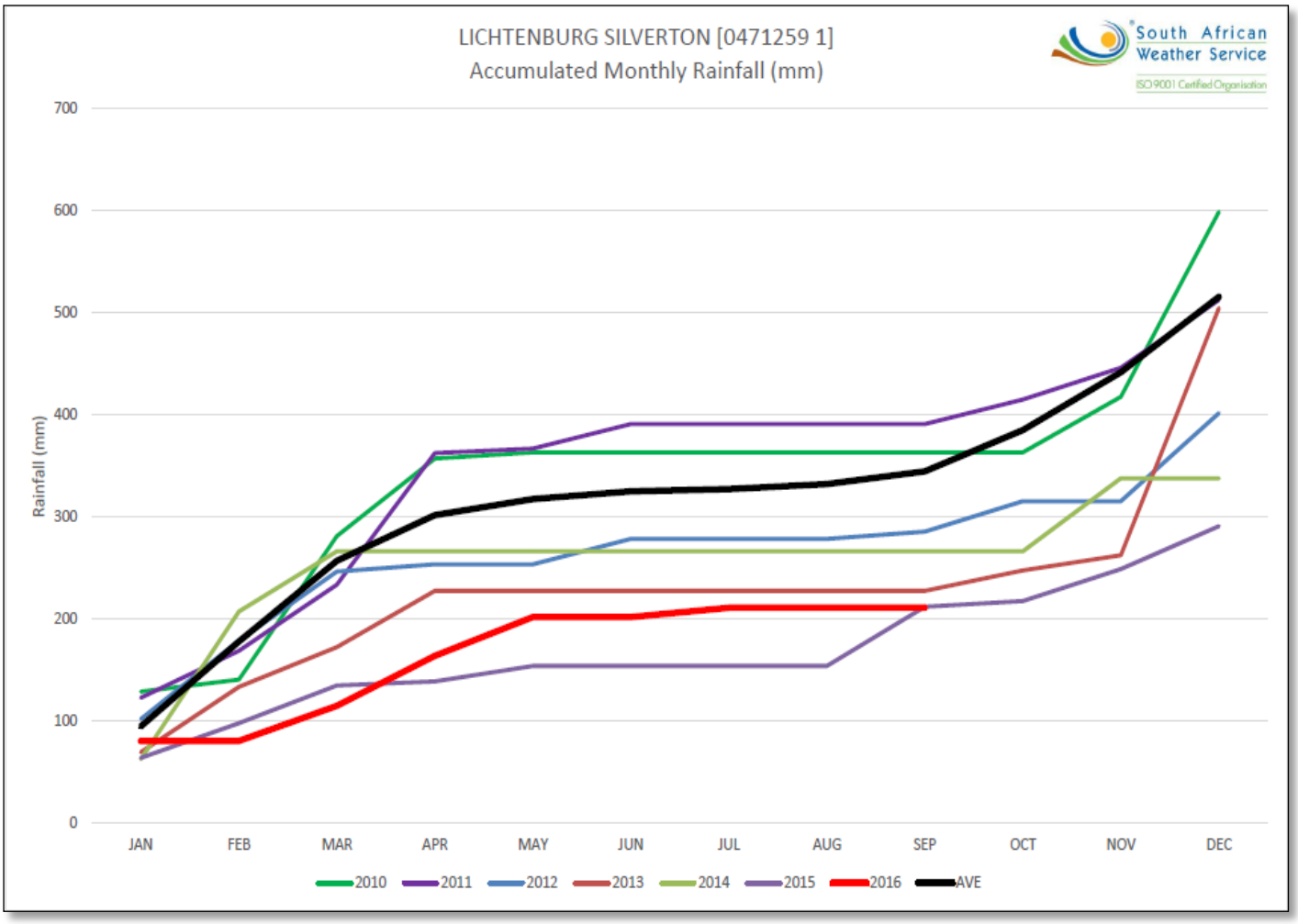


Figure 4.1: Accumulated monthly rainfall: Lichtenburg Silverton (Source: SAWS, 2016).

This observation led the researcher to wonder whether the lower rainfall over the past four years was a trend that supported the theory of climate change or whether it was merely indicative of a protracted dry cycle. This lived experience could potentially influence and skew participant perceptions of climate change. One of the expert participants reinforced this concern: *"The climate has changed but this is not proven statistically. Perceptions and experience are not necessarily proof of change; we could*

*just be in a dry cycle. How do you perform a regression analysis on such a brief moment in history?"*

The researcher was alerted to the personal collection of rainfall record books and it was while perusing these that the record of SAWS rainfall recorder, Mr T. A. Young, *The Miracle of 1933/4* (see Appendix D) was discovered. An extract of the diary entry is shown in Figure 4.2. This records "terrific winds", "drifts of sand", hedges "buried in 3 feet of sand" and "veld that had the appearance of a desert". The livestock were dying and "the outlook was terrible".

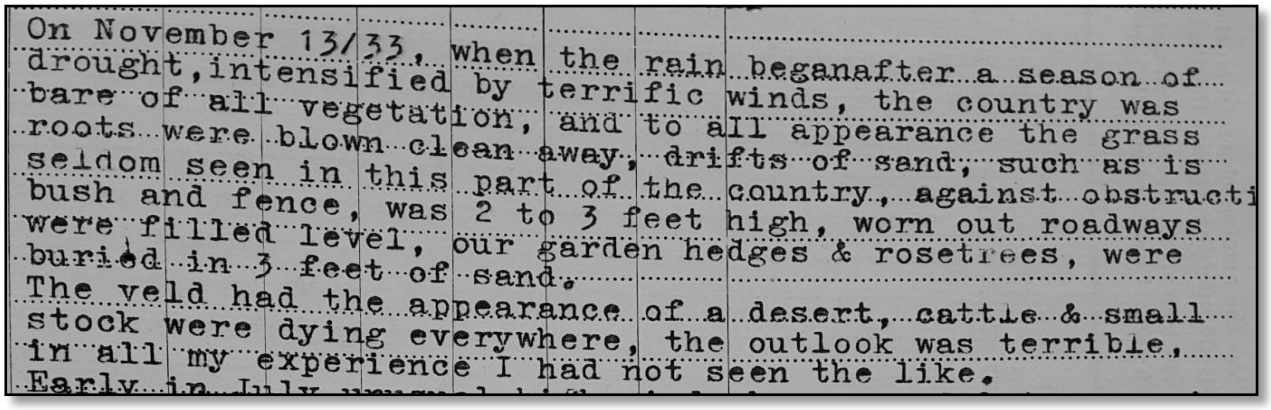
On November 13/33, when the rain beganafter a season of drought,intensified by terrific winds, the country was bare of all vegetation, and to all appearance the grass roots were blown clean away, drifts of sand, such as is seldom seen in this part of the country, against obstructi bush and fence, was 2 to 3 feet high, worn out roadways were filled level, our garden hedges & rosetrees, were buried in 3 feet of sand.
The veld had the appearance of a desert, cattle & small stock were dying everywhere, the outlook was terrible. in all my experience I had not seen the like.

Figure 4.2: Mr T. A. Young diary entry: The Miracle of 1933/4 (Source: Mr J. A. Mathews, 2016)

That report could have been written in 2015-2016 if one compares the diary entry to the photograph in Figure 4.3. The diary entry in 1934 and *in situ* evidence of 2016 could indeed demonstrate the cyclical character of the climate in this region with very dry seasons followed by good rains (Figure 4.3).

Figure 4.3: Photograph taken at Mooifontein on 8.10.2016 (Source: Own contribution)

The diary entry also tells another story, of how forgiving and responsive the soils in this region were when the rains did come. This substantiates the findings from both the desktop review (DEA, 2015a:63) and the interviews which held that the region has high potential cropping soils and rangelands.

> *"During January, on 22 days (sic) we had 10.36 inches of rain, sunshine came with the beginning of February, and by the end of the month the miracle had worked, our veld was a sea of waving grass in seed."* (see Appendix D).

A sample of photographs (Figures 4.4 - 4.9) has been included since they contribute to thick, rich description. A brief analysis follows:

- Figures 4.4 and 4.5 illustrate the good sunflower and maize crops standing tall in fertile soils. These confirm that this region is well suited to crop production at present.

- Figure 4.6 shows excellent arable fields that need urgent weed control in order to preserve soil moisture.

- Figure 4.7 is an example of traditionally ploughed land. Ploughing is still a common method of tillage but is no longer considered best practice in a region in which soil moisture conservation is critical.

- Figure 4.8 shows how some of the farmers have adapted their tillage system to minimum tillage by using tine implements rather than ploughs. This implement loosens the soil but does not expose the deeper, moist soils to sun and evaporation.

- Figure 4.9 shows a farmer applying total pre-emergence chemical weed cover. The farmers are increasingly aware that weeds utilise valuable soil moisture that should be preserved for their crops.

Figure 4.4: Sunflower field at Weltevrede, March 2013.

Figure 4.5: Maize growing in February 2013, Weltevrede.

Figure 4.6: Deelpan farmlands: Weed control is a widespread problem.

Figure 4.7: Tillage operations - widespread use of ploughing.

Figure 4.8: Vibroflexing is a step in the right direction.

Figure 4.9: Spraying total cover herbicide.

(Sources: Own contribution)

The second set of photographs (Figures 4.10 – 4.15) was taken on a field trip on 8 October 2016. The effects of prolonged drought including the 2015/2016 season were evident in the barren landscape.

- Figure 4.10 is of the natural veld (rangeland) near the villages of Lombaardslaagte and Brooksby. There was not a blade of grass in sight for grazing or soil cover.

- Figure 4.11 shows arable lands subjected to wind erosion of top-soils because there was no organic matter to protect the surface.

- Figure 4.12 was evidence of the dilapidated infrastructure that enabled the animals to move freely and confirmed there was no management of grazing and cattle could wreak havoc in planted fields.

- Figure 4.13 is of a crop land near Enselsrust, where thin animals were searching for food. The farmers reported that animals were dying on a daily basis by October 2016.

- Figure 4.14 shows more ploughed lands near Mooifontein that were subjected to wind erosion with no protective dry matter to protect the surface of the soil.

- Figure 4.15 is of interest because it shows two 15ha lands side by side that used different tillage systems. On the right is a traditionally ploughed field using a mould-board plough, while on the left there is a no-till sunflower field with some dry matter still protecting the top soils.

Interestingly, many of the photographs illustrate issues raised in the semi-structured interviews with farmers, e.g. the poor state of fencing which allowed animals to roam freely and ruin their crops.

Figure 4.10: Barren, deserted natural rangelands near Brooksby village.

Figure 4.11: Wind erosion over cropping fields near Lombaardslaagte.

Figure 4.12: Dilapidated infrastructure near Brooksby is a common sight.

Figure 4.13: Thin herd animals scrounging for food in a drought-stricken cropping land near Enselsrust.

Figure 4.14: Ploughed lands wait for rain. The livestock have eaten all the dry matter left after the harvest.

Figure 4.15: Cropping fields near Brooksby: the contrast between lands tilled by a mould-board plough (right) and no-till lands (left).

(Sources: Own contribution)

The conclusions that can be drawn from these opportunities of non-participatory observation do not particularly contribute to the argument either for or against the theory of climate change; however the information does confirm that the Mooifontein region is prone to dry spells and extremely high temperatures. This is significant since almost all the farms are based on rain-fed agricultural systems. The SAWS report trendline (SAWS, 2016) (see Appendix C), further confirms that the annual rainfall is trending downwards. The photographs serve to confirm that, while there is undoubted potential for both crop and livestock farming in the Mooifontein region, the dry cycles characterised by very low rainfall, high temperatures and strong winds negatively impact the sector. In light of the statistical and physical evidence available, the researcher supports the opinion offered by Vogel (2008) that CCA farming should be taught to farmers in order to secure sustainable production and build the resilience of the farmers.

### 4.3.2 The semi-structured interview process

The semi-structured interviews were initially tested in pilot interviews with one farmer and one expert. On their advice, small changes were made and the final interview guidelines are attached as Appendix A and Appendix B.

#### 4.3.2.1 Analysis of farmer participant feedback

A summary of the background information supplied by farmers is attached (see Appendix E). The researcher found it significant that the average age of those profiled was above 50 years since it highlights a problem for the future. It will be a serious problem when these farmers are old and their traditional knowledge and experience die away. If members of a younger generation are not entering the sector to learn through a mentorship process and acquire experience at the hand of those who have walked the road, food security and rural livelihoods will be threatened. A 40-year-old farmer observed that he was the second youngest commercial farmer in the Mooifontein region. The two female farmers were both old and tired: *“The sun is too warm for me these days. I don’t know if it is sickness or old age or changes in the weather.”*

The discussions about farming activities were marked by an undertone of desperation, particularly in the communal farming areas. Maize and sunflower cropping is threatened by poor infrastructure, livestock raiding the crops and large-scale theft by villagers.

Some farmers will not plant maize on communal lands again (see Figure 5.1). One farmer is planting a soybean trial because he has heard there is no theft problem associated with this crop. This crisis is exacerbated by the hot and dry climate and the droughts recently experienced. Even where theft is not the main problem, maize planting has become risky because of the high costs and low profits. One farmer bemoaned the fact that to get a crop in the ground, *"I have to scratch every last cent out of my pocket every year!"* The result is that farmers are planting more sunflowers than previously and are considering planting other crops such as sugar beans, soybean and pastures.

There are fresh insights into the value of soil moisture conservation. Large-scale farmers have already moved over to conservation tillage. Some small-scale farmers plough but others use tine implements (conservation tillage). Most of the participants practise total cover weed control using chemical sprays and those still practising mechanical cultivation acknowledge that cultivators expose the soil too much. Most farmers favour fallowing to rest the soil and build moisture levels, but for some this is a luxury option.

The livestock component varies considerably. One large-scale commercial farmer places a large emphasis on this aspect since he is wary of the risks associated with cropping. Another mentioned that, *"In the old days farmers believed that every hectare of cropping land should be matched by one breeding cow, because that brought balance to a farming enterprise".* Other farmers agreed with this approach, but highlighted the challenges of raising livestock on communal rangelands.

The focus of Section 3 in Interview Guide (A) was on understanding farmer's perceptions of climate change and other threats to sustainable farming in the Mooifontein region. Some were sceptical: *"I don't buy into the theory of permanent climate change. I believe there are natural cycles and we are in a hot cycle right now,"* and *"Current conditions are different from 30 years ago but data is not yet recording real change. I think our perceptions have changed, not the reality"*. Others believe there have been changes, such as a later onset of summer rainfall, but hesitate to concede that this is permanent. One farmer said he was still acting on his father's advice from 30 years ago. He said the best maize yields in the region were planted from the last week

in November into the first week of December. Some farmers understood that climate change would force farmers to change *"from tilling to minimum or no-till to retain soil moisture"* and another added that the last three years had been unpredictable: *"We don't know what to expect anymore".* One adamant view was that nothing had changed, because the 1980's were also dry like now - there have always been wet and dry cycles - *"But now the dry years seem to be one after the other"*. Others said they did not understand what was meant by "climate change".

Changes identified in weather patterns included:

- high winds and sandstorms;
- heavy rain when it does fall;
- higher day and night temperatures;
- high temperatures causing crop damage and scorched leaves;
- planting season starts later – *"actually much too late"*;
- planting later means frosts could threaten the crops before they are mature; and
- much less rain than normal – "Brooksby used to be called 'the place of rain'".

The researcher found that the farmers preferred to think the current experiences of climate changes were characteristic of a dry cycle that would pass. There was a prevailing scepticism about the theory of climate change, although it must be said this had not negatively influenced the farmers' attitudes to adaptation as a tool for risk mitigation in this dry, hot region. All without exception were open to adopting new farming methods to mitigate climate risk.

Most of the farmers agreed that the region was suited to maize production, with other cropping options being sunflowers, groundnuts, sugar beans, soybean and pastures. *"We can adapt and continue growing cash crops. The pressure is from an economic rather than an environmental point of view."* Some of the challenges identified were:

- Late rains;
- Being forced to plant later with the risk of frost on immature crops;
- High temperatures that dry the soil and scorch plants;
- Climate change;
- Theft of crops - green mealies, dry maize, sunflowers, groundnuts;

- Animals grazing in the crops; and
- Low market prices.

In light of the above challenges, a few of the farmers were pessimistic about the future of maize cultivation in the region and one commented that, *"farmers are increasingly turning to sunflowers as the primary crop rather than the secondary crop it once was".*

The general consensus was that the region should be well suited to livestock farming, which would help to boost cash flow; however the current scenario was defined by access to land, which led to vastly polarised experiences. Farmers on private land were convinced of enterprise viability, while cattle farmers using communal grazing were burdened by challenges arising from shared decision making – *"In the past Brooksby farmers worked together and agreed on which camps would be rested. But now it's a 'new democracy' and it's a free-for-all; there's no mutual respect or cooperation".* The drought has taken a toll on the grazing and resulted in animals dying. Two farmers highlighted the importance of building up good fodder-banks to carry cattle through winter and early summer. Some challenges noted were:

- Overgrazing;
- Poor management of grazing*;*
- Too many animals;
- No recovery period for the grass;
- Grazing camps have deteriorated and are full of ant-hills;
- Poor fences and theft of new fences;
- The risk of disease from other animals that are not dosed regularly;
- The risk of infertility because inferior bulls might serve the cows;
- The veld and crop residues have to be managed carefully – fodder is costly;
- Poor rains have resulted in low yields so there is a reduced fodder supply; and
- Cash flow requirements force farmers to sell off animals, and calves are weaned and sold off earlier than is ideal, all of which lowers profits.

The farmers agreed that the biggest challenges for the 2016-2017 year were accessing production finance, finding cash to cover regular overheads and the risk of further disasters such as drought. *"We are highly stressed. There have been many deaths*

*around us – animals are dying of hunger and farmers are dying from stress."* Another farmer said, *"We have buried many of our animals, but the people are also dying from stress. Sometimes I can't sleep at night."*

In Section 3.2 of Interview Guide (A), the researcher enquired about the farmers' insights into climate-smart agriculture and sustainable farming practices. The large-scale farmers were all aware of climate-smart farming systems and many felt they had already begun implementing CSA by shifting to CA and greater use of information systems and tools offered by modern technology: *"For the past 30 years I have been working IN nature, but over the last 5-8 years I have changed my approach and now I am look for opportunities to work WITH nature by exploiting natural resources, but keeping everything in a sustainable balance."* Most of the small-scale farmers were unsure what the term 'climate-smart' meant and some surmised it had to do with changing tillage systems and conserving soil moisture.

All the farmers agreed that soil moisture conservation and health were critical. However, there were mixed views on whether no-till would succeed in the long term, with strong opinions held on both sides of the fence. Some said they were not convinced by what they had seen in the region so far: *"The biggest no-till farmer in our area is dealing with huge challenges"* - and thus have opted for a minimum till approach together with other precision farming practices. The problem is that none of the farmers can afford to risk experimenting due to their small profit margins and high cost of new tractors and implements. The only fully committed no-till farmer also said that no-till farming required excellent weed control, which is expensive. He acknowledged that costs had been incurred in the process of adaptation; however he insisted that *"the cost savings have been significant"*. The point was illustrated as follows:

- In 1983, 600ha were planted by 12 tractors, each running 1000 hours/year which equates to 12 000 tractor/man hours/year;
- In 2015 under the no-till system, 1400ha were planted by one tractor using 286 tractor/man hours/year and 140 tractor/man hours for chemical weed control with a high-rise spray.

*"The end result is I can be more efficient and I can plant more hectares, using less mechanical hours and less labour".*

Precision farming is considered key to future efficiency because the information gathered and the precision with which seeds, chemicals and fertilisers could be applied cuts costs significantly. Other adaptations described were:

- Seed population;
- Accurate fertilisation using soil samples;
- The use of Roundup Ready® seed and Roundup chemicals for weed control;
- Ripping soils deeper so that moisture can filter deeper;
- Plough less;
- Use newest spray technologies; and
- Elimination of weeds.

The farmers agreed that there were costs attached to change and many said they could not afford to risk failure, while one said, *"Can I afford to risk trying new things? The truth is I can't afford not to!"* All were positive about climate-smart farming and said they would be willing to adapt if this meant building their resilience to the hot and dry climatic conditions: *"We have made many changes already that have helped us; we can still improve more."*

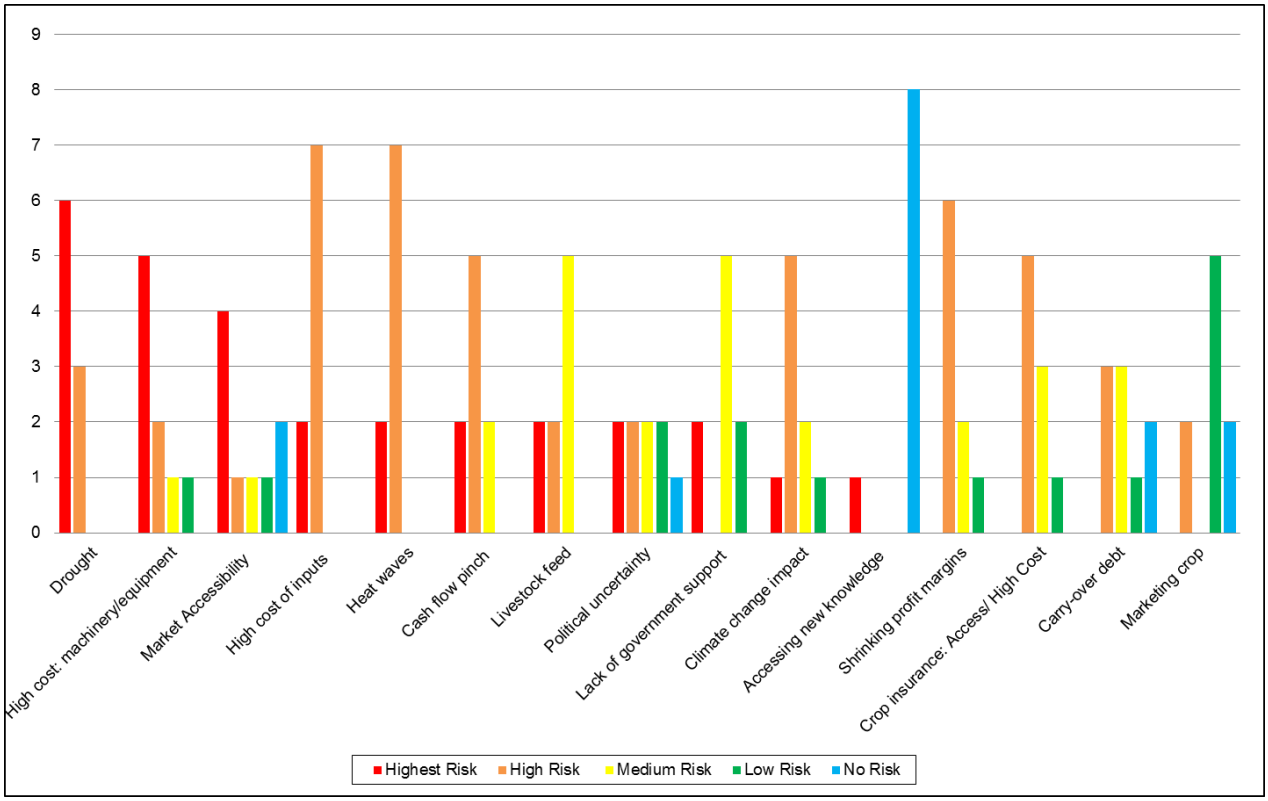


Figure 4.16: Farmer Risk Perception Index.

The Risk Perception Index (see Figure 4.16) shows that farmers have different stressors, depending on their unique set of circumstances. The highest risks (illustrated by the red and orange columns in the graph) are perceived to be drought and high temperatures, as well as economic pressures from the high cost of inputs, the cost of machinery and shrinking profit margins. A particularly interesting result reflected that most farmers do not see accessing new knowledge as a risk factor (see the highest blue column). The other noteworthy result is the response to 'lack of government' support which is viewed as a medium risk. This speaks to the independent and resilient characteristic of farmers who believe they have to rely on themselves saying things like, *"We must help ourselves"*. The index revealed disparate views on the risks accompanying political uncertainty.

The farmers' perceptions of DRR and knowledge management were explored in Section 3.3 (Interview Guide A). They showed a basic understanding of DRR that included planning, preparing and taking out insurance to lower the risk and help them survive *"tough times"*. One farmer said this region had been declared a disaster area and the government's efforts at drought relief aid had arrived in the form of four bags of feed for his animals, which lasted one week. Climate change was perceived by most to be a hazard, but since this could be managed, it was not perceived to be a disaster risk. There was consensus that farmers needed to adapt to reduce risk: *"It's an educational process and not an overnight thing."*

There appears to be little effort at knowledge transfer in the region, other than by Grain SA with their study groups and NWK farmer information days. One farmer felt there was a lot being done by the Maize Trust, e.g. the Conservation Agriculture programme seated in Grain SA. Networking with other farmers and organisations seemed important.

The role of extension officers in knowledge transfer is questionable, because most of the farmers said they were not often in the field and they were not very knowledgeable anyway. One farmer commented on how different the service was from his father's era, when extension officers were active and knowledgeable about best practices. Attention was drawn to the government's assistance of *"emerging farmers"* in the form of recapitalisation grants and production input grants but, *"grants to farmers are poorly*

*managed and the chain of benefactors before the money reaches farmers is too long". "I was supposed to be helped with a full grant to plant 100 ha but they only delivered 100ha seed and 2500l diesel"*. Another reported that, *"I can't tell you who managed the (grant money) finances last season. We just suddenly see them planting in our fields. The work is all done by contractors; we do nothing. They don't even use our tractors; instead they pay contractors to do work we could do."* This government intervention was done in spite of the fact that this farmer has new tractors and implements, and many years of farming experience and was quite capable of doing the job.

Concluding remarks by the farmers are that the sector was under severe pressure and the region needed normal rains and a prosperous season but they were still hopeful it would go well again.

#### 4.3.2.2 Analysis of feedback from the agricultural experts

There were six participants in this study, including the snowball sample. All the participants were male, apart from the snowball participant, and all of them had been educated in agricultural disciplines. The age, gender and work environment of the participants are listed in Table 4.1.

Table 4.1: Summary of Agricultural Expert profiles

| | Age | Gender | Field of work |
|---|---|---|---|
| Expert #1 | 60-70 | M | Maize Milling/ Farmer/ Mentor |
| Expert #2 | 50-60 | M | Agri-business - agronomy |
| Expert #3 | 50-60 | M | Agri-business – soil scientist |
| Expert #4 | 50-60 | M | Farmer-Mentor |
| Expert #5 | 30-40 | M | NGO: Farmer Development |
| Expert #6 | 20-30 | F | Seed Company: Plant production |

In exploring expert insights into climate change and other risks for sustainable farming (see Interview Guide B, 3.1), the dominant opinion that emerged was that climate had a cyclical nature and a dry cycle was currently being experienced. One participant reported that old farmers believed that 7-10 year hot-dry cycles were normal for the region. There was consensus that the climate has changed and most noted that the

seasons had shifted, and that the summer rainfall arrived later than before, with one commenting on how cooler temperatures extended into September-October. One expert emphasised that human activities were a concern: *"We are hammering the earth and we are going to trigger a negative climate pattern because of our activities such as burning fossil fuels and releasing GHGs into the atmosphere!"* Two of the participants were particularly adamant that climate change was a reality and a risk that needed to be managed through adaptation.

The participants agreed that *"it is definitely hotter", "the eighties weren't this hot"* and *"the heat is more intense"*. Another observed that, whereas temperatures normally ranged from 35°C-36°C, the past three seasons had produced temperatures as high as 40°C. Another expert highlighted that *"last year was the worst season in a hundred years"*. However, another emphasised that it might be the protracted drought that caused skewed perceptions of high temperatures, because there were no supporting statistics for this observation: *"It's definitely different, but records don't prove this. Hotter years can be linked to the absence of cloud cover so it feels hotter to us. This is just a perception!"* This insight was shared by another expert, who said that when one feels and experiences the climate as dryer, even though the same amount of rain falls, perceptions are influenced, but that this was not based on science. There were mixed responses regarding changes in rainfall patterns, with one participant emphasising that there had been *"no change in rainfall but it is becoming hotter here – slightly, but it is".* But then another maintained, *"Average rainfall has declined and is no longer at the annual average of 650mm as in the past."*

Regarding droughts occurring more frequently, the feeling was that this could still be a feature of the cyclical pattern. More than one expert noted that they were not occurring more frequently, but *"the severity of the droughts is increasing and will continue to do so"*. Another expert who had lived in the region all his life commented that drought had always been a feature in this region, but the last 15 years seemed to have been erratic, with a few more dryer seasons interspersed with a few good seasons.

Responses to the question, "What do you think the future for maize cropping in this region looks like?" (see Interview Guide B, 3.1.5) can be summarised as follows:

There are undoubtedly challenges ahead, with one expert saying the situation looks *"bleak". "I believe the pressures of farming will eventually not make farming within the Mooifontein region profitable as input costs rise and the risk of climate change/drought increases"*. Discussion about speculations by outside experts (apart from the participants) that the climate zone will have changed so much over the next 50 years that this region will be a citrus-growing area due to the warmer climate, led to one expert emphasising the amazing resilience levels of farmers: *"We are very innovative... we will make plans and we will still manage to grow our crops here. We will have to adapt for sure, but in reality we are already adapting".* This soil scientist emphasised that the soils in this region were very good, deep soils, well suited to cropping, so the farmers could manage the dry spells. Another expert farmer/mentor added that to the west of Mooifontein it was dryer, but to the east the potential was still good, if managed well and if farmers adapted to farming in drier conditions. The key message was repeated that maize could be produced here if soil moisture was conserved. Another noted that *"the key here is not the amount of rain that falls in a season but how the rainfall is distributed across the season. How we manage our moisture is everything!"*

Other experts highlighted the fact that maize cropping was not under threat because of poor production but due to a lack of profitability; thus climate change was not the only stressor to sustainable production in the region. An interesting statistic provided by a participant who is an agronomist, revealed that at that point in time farmers were producing the exact same yields off 550 000 ha, as were being produced on a million hectares 30 years previously. Farmers are innovative and creative and this trend will continue in spite of some of the gloomy predictions. He believed this was evidence that farmers had the capacity to diversify and adapt and to produce more with less. Another optimistic opinion was that there was always a good market for maize.

Respondents to the question, "What do you think of the state of the rangelands in the region?" (see Interview Guide B, 3.1.6) made the following observations:

The Mooifontein region is well suited to livestock farming and there are good opportunities there in spite of the threat of climate change. The agronomist expert advised farmers to identify their marginal lands and remove them from their cash cropping system to rather plant pastures for livestock. There has been much innovation

in livestock grazing systems that could give more impetus to livestock production here in the future, e.g. high pressure grazing systems. Another expert said farmers need to pay attention to building up fodder banks to carry the animals through the winter and until the rains arrive – *"and remember it doesn't rain grass…the grass must still grow after the first rains".*

All the experts commented on the massive problem of overgrazing on the extensive communal lands of the Mooifontein region. The potential of the veld in the region is drastically diminished: "*The rangelands in the Mooifontein region have been overgrazed for 50-80 years now."* There is great potential here but there is no management of the grazing lands and little chance of rehabilitation: *"The veld is so degraded the grass can't recover";* and *"even if we get a lot of rain in this area, the grass in the communal grazing areas will not recover because there are simply too many animals in the fields".*

A viewpoint held by a number of the experts was that climate change would affect livestock farmers less than the crop farmers, so the challenges should be addressed as a matter of urgency: *"Somebody will have to get government on board to develop grazing crops for the livestock"*.

The question, "How do you think changing climate is affecting farming businesses?" (see Interview Guide B, 3.1.7) was met with a qualified response by all the experts:

Businesses are precarious and insecure but this is not only due to climate change but also the consecutive drought seasons. All agreed that the farmers would have to adapt their farming systems in order to survive. *"For sure, climate change is a problem; but the problem is much, much more complex. There are many other contributing factors bringing risk to sustainable farming enterprises such as: politics, cost of labour, labour productivity and the high input costs, which are growing faster than farmers' incomes which leads to the 'kosteknyptang' (cost pinch)"*. The bottom line is that financial survival depends on income minus expenses and when you have lower yields and variable income then risk is high. Another concern was the high level of carry-over debt burdening farmers in the region: *"With drought years, carry-over debt is a necessity, but if this is followed by another drought season, it is only a matter of time before the farming business goes bankrupt".* Another observation was that the adaptation of

farming practices was key to long-term sustainable production and those farmers who did not adapt would not survive: *"It's like a process of natural selection"*.

The next set of questions (see Interview Guide B, 3.2) focused on establishing familiarity with climate-smart farming practices with the aim of getting them to assist in identifying region appropriate practices for CCA.

All the experts were familiar with the concept of climate-smart agriculture (CSA). The key message emerging from their responses was that the major issue here was soil moisture conservation and farmers needed to adapt their practices: *"It's ALL about water management"*. For example, this can be managed through minimum and no-till tillage methods, chemical weed control measures (not mechanical cultivation) and the use of adapted seed cultivars. It was necessary to access all available information to make informed decisions. One expert emphasised the importance of working with nature: *"Whatever you do in production must be in balance with nature".*

There was agreement that some climate-smart practices were already being implemented by some leading farmers: *"they are in the process of changing",* but there was not nearly enough adaptation to changed climate at this stage: *"Methods have improved but generally farmers in this region are not at the precision farming level".* An expert expressed concern that too many farmers were not computer literate, so they could not access the *"massive library"* available on the world-wide web. Commercial farmers are moving into new systems such as minimum tillage, fallowing (resting) fields, cover cropping, using improved seed cultivars and crop rotation. The conclusion is that there is enough evidence that farmers do adapt.

All were agreed that the Mooifontein region was very well suited to CSA. The following list is a summary of the participant experts' advice about suitable CSA adaptations from questions 3.2.4 and 3.3.5 (Interview Guide B):

- Adopting CA practices;
- Adapting tillage systems;
- Practising compaction control ('spoorverkeer'/ track control) over fields;
- Water infiltration can improve to ensure moisture penetration to below 40cm;

- Using herbicides not cultivators for weed control;
- Selecting drought tolerant seed cultivars;
- Diversifying and planting a wider variety of crops;
- Practicing crop rotation on the fields;
- Planting lower plant populations – but not so low that yields are compromised;
- Fallowing some fields each year;
- Making use of accurate weather predictions which offer useful information for cultivar selection and timing of planting;
- Widespread use of genetically modified seed, which is resistant to pests and glyphosate tolerant (Roundup Ready®);
- Mapping of soils improves decision making for fertilisation with cost benefits;
- More residual crop matter is left on the surface of the soil nowadays to protect against evaporation and wind erosion;
- Better results are achieved by paying attention to soil health and nutrition status;
- Technology should be harnessed as much as possible, e.g. penetrometer tests to test for plough pans (hard, impenetrable layers in the soil) and soil moisture monitoring; and
- Livestock should be kept off cropping lands to preserve crop residues on the soils.

The general consensus was that though climate change gave cause for making adaptations to farming systems, there were more serious stressors giving impetus to current adaptations, such as economic pressures and the high cost of inputs accompanied by low yields resulting from climate stressors which lowered profits.

A Risk Perception analysis (See Figure 4.17) was performed to gain insight into what these stressors were since the objective was to understand the extent to which the climate change issue challenged the farmers.

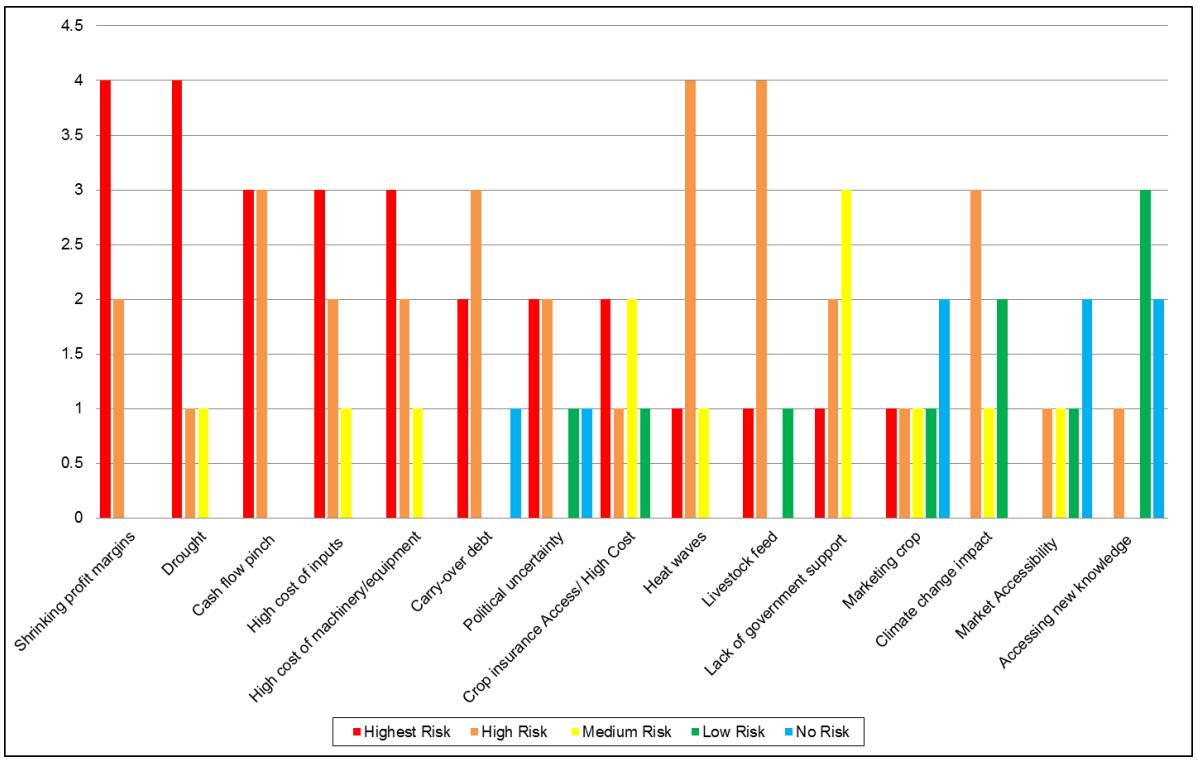


Figure 4.17: Agricultural experts Risk Perception Index.

The economic stressors are confirmed in these results, e.g. shrinking profit margins and the cash flow pinch, but climate stressors still rate among the highest on the Risk Perception Index. This was not anticipated by the researcher, since much more emphasis had been placed on the financial stressors during the interviews. Of interest is that the experts viewed political uncertainty as higher risk than the farmers did. This exercise highlighted the fact that a wide range of stressors currently threaten sustainable agriculture in the Mooifontein region.

The last question (see Interview Guide B, 3.3) focused the lens on expert participant insights into DRR and knowledge management, particularly since the experts are often involved in knowledge transfer. There was an understanding that the ability to lower vulnerability to disaster risk required planning and preparation to reduce risk. DRR in climate risk management which includes planning, preparation, savings and insurance for tough times, was seen as a support system for farmers. Climate change was largely viewed as a hazard but not a risk, since it could be managed with knowledge acquisition and adaptation interventions. There was consensus from both farmers and the experts that more research on region-specific CSA opportunities needed to be conducted and, furthermore, the current research standards were poor: *"Not much research is being done and what is done is not worth a lot"*, and *"the ARC used to be*

*unbiased but now the results are unreliable… it's 'monkey-business!'"* The observation was made that numerous farmers conducted their own trials in the absence of reliable information.

The participants all agreed that the contribution made to agriculture by government extension officers was no longer what it once was. In years past the expertise was authoritative and reliable. Extension officers made a vital contribution to the sector and they were highly regarded. This was not found in the field anymore and in general extensions officers lacked practical knowledge. Grain SA was identified as a leading farmer development initiative. Local agribusiness NWK also has a development programme which collaborates with input suppliers of seed and fertilisers etc.

The most effective methods of communication with farmers are considered to be through "*word of mouth", "to see is to believe"* and *"showing the proof"* of what could be achieved at Farmer Days and in study groups. *"Written articles tickle farmers' interest, but on-farm practical demonstrations do the convincing"*. Some were of the opinion that mobile phones were a useful tool, while others cautioned that the messages become easily confused and misinterpreted. Others confirmed that the most effective communication of them all was one-on-one but said that this was too costly most of the time. Other effective forms of communication available are radio services and magazines such as Grain SA's *Pula-Mvula* magazine, published in indigenous languages, the *SA Grain* and *NWK Arena*.

General comments on the process of adaptation focused on the psychological aspect of change:

- *"There is a basic resistance to change… it's a 'kop ding' (a head thing). It's too easy to stay in a comfort zone";*
- *"To change requires energy and commitment. It's easy to stick to traditional ways. To change means you face a challenge and may become tired and frustrated"; and*
- *"We have to adapt and we have to change. Those who don't won't be in agriculture in the future".*

Other observations made by the experts highlighted the human element further:

- *"Traditional practices have not kept up and there are very few father-son handovers that see a transfer of knowledge from one generation to the next";*
- *"In the past development projects like Agricor had the lands in full production but they failed to train farmers to farm, so once they left, everything fell apart";*
- *"The communal farming system is failing. There are thousands of hectares lying unproductive, overgrazed and covered with ant-hills"; and*
- *"Local land reform initiatives have been haphazard and don't follow through, e.g. a five-year recapitalisation programme lasted one year and then left the farmers to struggle on alone".*

The sector is clearly depressed, but there was a message of hope for farmers in the optimistic observation that, *"the need for food will drive farmers to be innovative and will create opportunities that will make farming profitable again"* but this was accompanied with the warning that farmers would have to adapt. Another expert's plea was that, *"we desperately need more experts to teach farmers about climate change and adaptation in this region".*

## 4.4 SUMMARY OF FINDINGS

In this chapter the findings of the field research were discussed. In this section these empirical findings were reviewed in light of the findings in the literature review as discussed in chapters two and three. An effort was made to discover common themes between the literature review and the empirical inquiry within the context of the research questions described in chapter one (see Section 1.4).

**Research question: What influence does climate change have on the agricultural sector?**

The findings of the desktop survey revealed widespread consensus amongst scientists and practitioners in the field of DRM that the climate was indeed changing and therefore agricultural activities were at risk (Wisner *et al.*, 2012:207). The regional information for the NWP in which the field of study lies (DEA, 2013: 120-121) stated that long-term

predictions for the region of study was a steady drying from 2015 – 2035 and that annual temperatures would increase by up to 2.5°C. The literature review also highlighted that the African continent was likely to feel the impacts of climate change more severely than others (O'Brien *et al.,* 2008:10), in particular where communities were already vulnerable as a result of poverty, sickness and marginalised livelihoods (Speranza, 2010:16). It was found that change was already experienced and the summer rains were starting later and the "planting window" was later (DEA, 2015a:67). The findings of the empirical survey would appear to reflect this theory. Farmers and experts alike described many *"changes"* such as later onset of the summer rains to start the new planting season, higher temperatures, lower rainfall, heavier rainfall with more run-off as against a well distributed pattern of rainfall across the growing months, all resulting in stressed crops and lower yields. The participants had varying opinions about the drought but some noted the severity of the dry spells which were confirmed in the findings of the study conducted by Botai *et al.,* (2016:20) that found the droughts in NWP were tending to be "more intense". Many of the challenges characteristic of climate change, like poor yields and seasonal unpredictability were highlighted by the participants and were already threatening sustainable agriculture in the region of study. However it must also be emphasised that the empirical survey found that the pressures on the Mooifontein agricultural sector could not be blamed on climate change alone. Many farmers were already trapped in difficult predicaments which made them vulnerable and struggling to cope with numerous other stressors (Speranza, 2010:16; Reid & Vogel, 2006:196). The hardship and the stress levels were heightened because of poor infrastructure, crops that were stolen overnight, marauding animals in the fields and herds weakened from grazing on depleted grasslands. These insights should raise concerns as to how the farmers will cope as impacts of climate change are more keenly felt.

**Research question: How well developed are the levels of awareness of climate change as a phenomenon in the Mooifontein region?**

In spite of wide acceptance that climate change was a reality, the participants in the study offered a range of opinions about climate change that varied from unreserved scepticism about the theory of climate change, to theories based on generational beliefs (what the old people used to say), such as the cyclical patterns of the climate. Other

participants only showed a vague understanding of what climate change was. It is significant that despite the disparate individual views, all the participants nonetheless agreed that the climate had changed, as discussed in the previous section. The researcher concluded that there were very mixed levels of awareness of climate change as a phenomenon. This was not in itself cause for concern. These opinions were at least the result of thought processes and had lead the participant/s to form judgements based on his- or her "world view": *"I think about it a lot"*. The real concern was for those farmers who had not been informed of the phenomenon, had not had the opportunity to learn about climate change and still held the view that each new season was simply "an act of God" (Wisner *et al.,* 2012:xxx). Those farmers had neither had cause to think about the risks that climate change holds for their farming activities nor understood that there may be initiatives that they could employ to change their "fate". This was in agreement with the findings from the desktop survey that confirmed that ignorance of climate change risk would compromise farming productivity and food security (Lal *et al.,* 2011:276).

According to the UNFCCC, climate change is a change in climate caused either directly or indirectly by anthropogenic activity (Wisner *et al*., 2012:207). Although some participants in the study were aware of the contributory role of human activity to GHG emissions, there was no evidence of a broad-based understanding of this aspect of the climate change issue. The general perception seemed to be that climate change was "a very big problem" that one individual was powerless to respond to. This should be cause for concern since a "business as usual approach" (Stern, 2006:144) heightens risk, with the real possibility of even greater losses. This supports the assumption that has underpinned the study and holds that there is a need to identify region-appropriate adaptation and climate-smart farming processes to be framed in a proactive adaptation education program.

**Research question: What are the theoretical approaches and perspectives on climate change and DRR, and which links can be established between the two schools in the context of farmer development and vulnerability?**

The literature review established that although DRR and CCA practitioners had always tended to operate with "silo" mentalities (Wisner *et al.,* 2012:1), there were critical

interdependent links between climate change and DRR in the context of farmer development and livelihood vulnerability (Mitchell *et al.,* 2010:2; FAO, 2013a:360). It was clear that an ideal development programme would simultaneously address climate risk because failure to do so would jeopardise development initiatives (Pettengell, 2010:33). The HFA 2005-2015 recognised that climate change mitigation and adaptation processes were effectively also tools for DRR practitioners. The literature review indicated that there had been significant progress in the more integrated approach to DRR (ISDR, 2005:15). DRR was more widely accepted as "the first line of defence" against climate change (Kadzatsa, 2011:20) with the recognition that both strategies aimed to reduce risk, build resilience to shocks and improve livelihoods. Whereas DM was focused on managing a disaster event, DRR took a long-term and visionary approach to hazards. Since climate change was by nature a slow onset disaster, the DRR lenses of risk profiling, mapping and risk communication (Van Niekerk, 2015:397) were considered appropriate for anticipating impacts and looking for solutions to inherent risks.

**Research question: What are the current climate change policies and legislation in South Africa?**

The desktop study highlighted that as far as the institutionalisation of DRR was concerned, South Africa had been proactive. A progressive DRM policy was entrenched in the Disaster Management Amendment Act 57 of 2002 (South Africa, 2002). Considerable investment had been made into climate change research e.g. the Long Term Adaptation Scenarios and formulating climate policy (DEA, 2011:46). The limitations became clear when searching for evidence of effective, long term interventions of DRR, because there was a glaring absence of this at municipal and sectoral level in the Mooifontein region. It could be concluded that the disaster risk reduction process is undermined at grassroots since although the Disaster Management Act may well be proactive legislation; the problem is the dearth of evidence of effective implementation, which limits the Act's overall efficacy. The case-study of the eThekwini Municipality (Roberts, 2008:521) (see Chapter 3.3.5), suggested that better informed policy makers were more inclined to support effective DRR, which adds further impetus to adaptation education programs.

It could be said that the current implementation of DRR in South Africa, through the officially designated channels, is failing the progressive approach adopted by government. Farmers' highlighted government's approach to development indicating that it had always been too easy to focus on getting farmland into production, rather than on developing the farmer and equipping him or her to farm sustainably. *"I hate to tell you how many millions of rand have been poured into agriculture in this region"* and *"There has been so much misdirected development*" or *"Development efforts have been erratic"*. The Agricor project (Kirsten & Van Rooyen, 2011: 270) that saw hundreds of hectares of farmland within the Mooifontein region become highly productive was a case in point. Once the project ended and the management was withdrawn, the local agricultural economy collapsed. The reason was likely due to the fact that the farmers were never truly equipped with the necessary skills to farm on their own (Bachtiar *et al.*, 2003:25). The empirical inquiry further revealed that this pattern of farming for farmers and making use of contractors was on-going. Provincial government projects were still following a top-down approach with apparently very little consultation with the farmers. It appeared the provincial government was making the same mistake all over again.

**Research question: What is climate-smart agriculture?**

The investigation into climate-smart agriculture revealed that CSA is a not one specific farming system but rather "a triple-win approach" that embraces sustainable farming practices towards improved productivity and food security, strengthening resilience to climate risk and lowering agriculture's contribution to GHG emissions (FAO, 2013a:ix). It includes CA and other tools and processes that create a more enabling environment towards achieving national development goals. The focus is on soil health and moisture conservation and other processes aimed at getting "more crop per drop" (FAO, 2013a:84; ARC, 2014). The CSA approach appears to offer solutions for the agricultural sector in the Mooifontein region since the literature review highlighted that agriculture is integral to the economy of the NWP and plays an important role in poverty alleviation (NWPG, 2008:237). The information from the empirical survey supports the view that this region has the potential to be a productive agricultural hub because the farmland is comprised of inherently high quality rangelands and deep soils that are well suited to cropping.

Climate-smart farming is an integrated approach that includes the farmer and the farming system in the process of building long term resilience into the production system (FAO, 2013a:ix), and sees the farmer as a key strategic partner in the development process (Cadribo, 2011:63; Kadzatsa, 2011:47). It was not apparent from the empirical survey, that the farmers experienced any form of long term, reliable support apart from what they had with Grain SA and NWK. The farmers most affected were those already more vulnerable because of the challenges they faced at the site of their farming activities. Those farmers, who had their own land, or rented lands far from the villages, were better off. It was disheartening to see that even where climate-smart practices had been implemented by farmers in the region, there were still too many others who were unaware of the positive contribution a climate-smart approach could make to their farming systems.

The pressure and release model (Wisner *et al.,* 2012:23) highlights the progression of vulnerability and the progression to safety. The progression of safety is a more resilient state achieved through interventions that address root causes and reduce the pressures in striving for safer conditions (Wisner *et al.,* 2012:31). The farmers demonstrated a willingness to embrace adaptation, and were unanimous that wherever improved, sustainable farming systems were identified, it was important to investigate the potential of building resilience into their farming enterprises. Some farmers acknowledged that some adaptations had already been made, while others emphasised that farmers are always evolving and embracing new technologies. This found support in literature that recognised that farmers are adaptable (DEA, 2015a:67). The participants believed that the future success of farming lies in the adoption of technology.

**Research question: Why is it important to transfer knowledge that will both inform and encourage farmers to be prepared to make changes and ensure that they understand the benefits of climate-smart agriculture?**

According to O'Brien *et al.,* (2008:21) there is a need for climate change information to be made more readily available, in more effective ways, so that the common goals are easily understood by other stakeholders. Vogel *et al.*, (2013:4) insist there needs to be a fresh approach to addressing the uncertainty accompanying a changing climate and

risk management processes. The empirical survey found that there was a knowledge gap in understanding climate change. There were risks for those farmers who were ignorant about climate change and the need to adapt to CSA systems in order to build resilience. It could therefore be deduced that the need had not yet been addressed and knowledge barriers still existed. Despite acknowledgement from the DEA (2015:69) that the most important element of successful adaptation to climate-smart farming lies in the hearts and minds of the farmers, there was little meaningful evidence of a government footprint on the farms. This is a weak link in the local development agenda. The empirical research highlighted that both the farmers and experts agreed that the most effective form of knowledge transfer is 'one-on-one' and "by word of mouth". They also agreed that progress is made where the farmers can visually experience new ideas – "to see is to believe" – and they have a good appetite for information days where they can witness demonstrations and visit trial plots where the benefits of different practices are highlighted. The farmers were also positive about radio and agricultural magazines as sources of information.

**Research question: What is the nature of land ownership or access to farmland, what is produced by the farmers and what are the predominant traditional agricultural practices in the region?**

The interview process revealed that while a few farmers own land, many rented additional lands or had access to communal tribal land. Many factors influence farm profits but it became clear that those farmers using communal farmland near rural villages were severely challenged by theft, marauding animals and poor infrastructure. The reports that these farmers could no longer risk planting maize and that even sunflower crops were being raided were disturbing. The other crops suited to the region were sugar beans and groundnuts but these would be equally vulnerable to theft and cattle. Another issue highlighted during the empirical survey was that if a farmer did not hold the title deed for his land, and hence had no land for collateral, accessing production finance was almost impossible. This sentiment was echoed by the findings in a study conducted by Tau (2003:86). Reports about the disintegrating communal grazing system should raise alarm bells and give widespread cause for concern particularly since it is acknowledged that livestock farming will be less negatively impacted by climate change.

## 4.5 CONCLUSION

The focus of this chapter was on the findings of the empirical inquiry which was conducted in the Mooifontein region. The fact that the study was done over an extended time period enabled the researcher to collect rich insights as a non-participant observer. The discussions with the participants followed a semi-structured interview style which was conducive to the collection of meaningful data. The data was analysed and processed to identify dominant themes. The findings from the empirical research process were then summarised and compared to the findings of the literature review. The aim was to identify commonalities and to determine if the literature verified the findings from the field research. To a large extent this was found to be the case and many common themes were identified. The findings from both the literature review and the empirical study were then analysed in light of each of the research questions posed at the outset of the study.

In chapter five conclusions were drawn based on the findings in chapter four. A discussion, on the final research question of this study that asked what an effective adaptation education programme would look like, follows. Insights gained from both the farmers and the experts formed the basis of the recommendations made for an adaptation education programme to facilitate climate change risk management in the Mooifontein region.

# CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

## 5.1 INTRODUCTION

The empirical research conducted in the Mooifontein region and described in chapter four gave the researcher rich insight into the everyday lives and challenges faced by a broad cross-section of the farming community. The opportunity to conduct interviews with farmers provided insight into the inquiry through two polarised lenses, namely, those of the farmers and the agricultural experts, who offered perspectives out of disciplines such as agronomy, plant production, soil science, farmer development and agricultural management. Whereas the findings in the field are outlined in Chapter four, Chapter five concludes with a final discussion about issues highlighted in this study. Finally the recommendations about reliable climate-smart initiatives, that were deduced from the interviews and could be included in an adaptation education programme, have been summarised.

## 5.2 GENERAL RESEARCH INSIGHTS

The motivation for this study was an inquiry into how the Mooifontein region might be impacted by climate change risk in light of the fact that it is primarily an agrarian-based economy. The literature review in chapter two indicated that climate change was affecting natural resources and biodiversity; thus agriculture would clearly experience growing pressure from climate change. Furthermore it was highlighted that effective adaptation towards building livelihood resilience could be characterised by a cross-sectoral, multi-disciplinary and multi-pronged approach, whereby stakeholders cooperate in development programmes for the sake of a common goal, namely, to improve the lives and livelihoods of marginalised peoples and to contribute to developing and implementing sustainable farming systems that will be effective in the region.

Successful CSA and CA farming systems were also highlighted. It is recognised that it is one thing to know of the potential successes of effective adaptation, but entirely another thing to fully understand the intricacies of the adaptations and then to actually implement the processes. It was found that, apart from adaptation knowledge, climate change adaptation brings with it a financial burden that is usually carried by the farmer. The literature further highlighted that existing knowledge gaps were barriers to transformation. Knowledge transfer has many challenges, so one of the aims of this study was an exploration of the quantity and quality of climate change adaptation information being channelled to grassroots. This was to lend support to one of the key research questions asked at the outset of the study, namely what a successful adaptation education programme for farmers in the Mooifontein region would look like. It was suggested that the findings of this study might contribute to the adoption of climate-smart practices by identifying realistic opportunities for conservation farming and climate-smart farming.

## 5.3 RECOMMENDATIONS FOR CLIMATE CHANGE ADAPTATION EDUCATION

The final research question posed for this study was:
**What would a successful adaptation education programme look like?**

The recommendations included in this proposal are those mentioned by the farmers and the agricultural experts who understand the Mooifontein agricultural sector. The experts are specialists in their field and familiar with the unique characteristics of agriculture in the region. Some of the adaptations had already been implemented by some of the farmers or they were adaptations they wished to make in the future, or if and when finances allowed.

### 5.3.1 Best practices identified for the Mooifontein region

The climate-smart farming practices listed below could serve as recommendations for the development of an adaptation education programme for agriculture in the region. Some useful recommendations towards building resilience into local farming systems have been summarised from the discussions held with farmers and agricultural experts, during the course of this study. They are as follows:

1. Utilise early rains as soon as possible;
2. Use ground water effectively and improve water infiltration into soils;
3. Move away from ploughing. Adopt conservation tillage practices like minimum tillage or no-till;
4. Learn about CSA and CA;
5. Build up soil health (hummus);
6. Learn about cover cropping;
7. Practise compaction control – this is very important in no-till systems;
8. Manage rangelands properly;
9. Get the livestock off the lands (especially communal croplands) so that organic matter can build up in the soil. Erect fences;
10. Carefully select seed cultivars. Plant adapted crops;
11. Weed control is critical during pre-planting, pre-emergence and post-emergence growth phases. Weeds are competition for crops for valuable nutrients and moisture;
12. Practise crop rotation to ensure more efficient uptake of moisture available in the soil profile and for soil health e.g. cow peas and beans release nitrogen into the soil;
13. Look for opportunities to diversify;
14. Convert marginal cropping lands to pastures for livestock;
15. Fallow lands to rest them and build up soil moisture content for the next season;
16. Use modern technology e.g. soil sampling, accurate weather predictions, market information;
17. Use modern tools like penetrometers to test for hard layers in the soil profile, monitor soil moisture; and
18. Plant population is important. If plant stands are too dense the plants will suffer in dry conditions and if too sparse the yields will be compromised.

It is clear that the Mooifontein region was already facing numerous pressures regarding sustainability, especially in the small-scale and commercial farming sectors dependent on access to communal lands. Among the many inherent stressors in the system, climate pressures were perceived to be high risk and contributory to the threat to food production and farming systems. There is much to be learnt about CSA and CA, but the prevailing body of knowledge on best practices for the Mooifontein region suggests there were already strategies that could be employed towards building resilience and ensuring that the best yields possible are produced under prevailing circumstance.

### 5.3.2 Bridging the knowledge gap

One expert suggested that farmers need a lot of reinforcing *"before the light bulb goes on"*, so knowledge transfer should embrace a number of communication strategies. It is also imperative that farmers become involved to the extent that they develop an ownership of the process. This is most likely to happen when they have been enlightened and have "bought in" to the goal of the knowledge transfer.

The most common methods of communicating with farmers in the Mooifontein region were through practical demonstrations and hands-on experience. Grain SA study groups were identified for their effectiveness, and as a constant presence in the region that provides reliable information and one-on-one assistance. The study group sessions include visual aids, open discussions and practical demonstrations. Modern technology used included power points and video clips to educate and demonstrate new principles. NWK, in partnership with other input suppliers, organise Farmers' Days that are informative and help farmers to build useful networks with other stakeholders in the sector. NWK has a development officer who is available to advise farmers and discuss financial support.

From the empirical research it can be concluded that there is not one perfect channel for communicating an adaptation strategy; it would be best to rather repeat the message often, using every avenue of knowledge-sharing possible. The fundamental drivers of climate risk knowledge sharing should be to:

1. alert the recipients to the inherent threat of climate-change risk;
2. inspire them through knowledge transfer to adopt an enquiring approach to opportunities for climate-smart farming; and
3. include all stakeholders in the knowledge-sharing process.

These recommendations need to be supported by more reliable and unbiased research into climate-smart farming opportunities on an on-going basis.

## 5.4 AREAS FOR FUTURE RESEARCH

The insights revealed by this study serve to emphasise the need for more research. Some suggestions on opportunities for future research are:

- This study focused on climate change risk but a broader investigation into the stressors threatening the viability of crop farming in communal farming areas such as the Mooifontein region needs to be conducted.

- The Mooifontein region has been found to be well suited to livestock farming under best practice conditions. Experts have also suggested that livestock farming will be less vulnerable to climate risk. The cost of leaving rangelands in communal areas unmanaged and under the jurisdiction of Tribal Authorities needs to be investigated and quantified.

- CSA is built upon three pillars, namely ensuring productivity and food security, building community resilience to climate change risks and lowering GHG emissions. CA is the most common adaptation process and CSA approach in the region of study. There is scope to conduct further studies on CSA in the region especially since both the literature review and empirical inquiry highlighted that the Mooifontein region and the broader NWP need CSA more than most.

- This study highlighted the need for knowledge sharing in as many formats as possible. At the same time the weakness in government agricultural extension services, which largely fail to contribute meaningful support to farmers, was also revealed. There is scope for an inquiry into the barriers to effective extension services since this seems to be ideally positioned for knowledge transfer.

## 5.5 FINAL REMARKS

This inquiry comprised an investigation into the need to build resilience in the agricultural sector through adaptation education using a climate-smart approach. It was found that regardless of whether the theory of climate change is accepted or rejected, it still holds true that agricultural activities in the Mooifontein region are subject to frequent periods of intense heat and drought that affect crops and grazing. It is therefore important that stakeholders in the sector take note of the depressed agrarian economy. Stakeholders from all sectors need to recognise that, while climate change is a threat, it is by no means the only threat to sustainable livelihoods in the region.

The following insights are noteworthy:

- While some farmers in the region have access to their own land and others are beneficiaries of land reform, many still access communal lands for their crop farming activities. Farming systems have already undergone a process of adaptation; the farmers focus more on soil health and moisture conservation to maximise opportunity to improve yields than ever before. The primary activities in the region are maize and sunflower cropping, accompanied by a livestock factor. Maize production is declining which is a major concern since this is a staple food. The survival of farmers who fail to embrace progress is under threat.

- While there is awareness of climate change, there is still debate as to whether the climate has changed or whether it follows a natural cycle of hot and dry spells. There is nonetheless consensus that the climatic conditions have negatively impacted farming businesses. All farming businesses are under pressure following protracted drought and poor yields.

- It is clear that the only exposure farmers have to climate risk- and best practice knowledge is through Grain SA's FDP and NWK initiatives. Other knowledge is self-taught, acquired through social networks or deduced from own research and trials. There is room for improvement in government extension services, which are an obvious channel for communication about region-appropriate climate-smart adaptation.

The spread of this study of the Mooifontein region has been particularly enlightening because it incorporated two vastly different farming systems that are apparently worlds apart, yet in reality no more than 10 kilometres divide them. The findings of this inquiry highlighted the fact that the farmers there face many common experiences and challenges whether they are small-scale or large-scale operators. However, those farmers dependent on the high potential farmlands and rangelands around the villages face a bleak future unless there are urgent interventions to counter the threat to sustainable farming in the region. The researcher did not anticipate the scope or

severity of the multiple challenges being faced by the farmers. It is suggested that these challenges makes climate change risk pale in comparison. So much so, that if these concerns are not addressed, there will be little farming activity left to be further negatively impacted by climate change. The “commons syndrome” that has led to the abuse and misuse of grazing areas (Tau, 2003:5) must be addressed and local tribal authorities need to be assisted to manage the rangelands better. The theft of crops and the poor infrastructure that enables the animals to roam freely also need to be addressed or soon the production of maize, a staple food, will be impossible. Too many role-players are blissfully oblivious to the true extent of this crisis. The Risk Perception Index revealed disparate views on the risks accompanying political uncertainty; however the researcher would suggest that since local tribal authorities are left with the responsibility of supervising the management of agriculture systems under their jurisdiction, this too is an insidious form of political risk. The current implementation of DRR through officially designated channels is failing the progressive approach adopted by government in the promulgation of the Disaster Management Amendment Act of 2015.

The study has highlighted that farmers are a resilient community. Without exception, all the participants in this study said they had already made changes and they would be willing to make further changes, if there was a promise of improved production and increased profits. They are also people of faith and hope. This theme was woven through many of the conversations; farmers and experts alike expressed their belief that current conditions would improve and farming would become viable and rewarding once again.

## 5.6 A LAST WORD

In the final analysis, the researcher arrived at the conclusion that the agricultural sector in Mooifontein region was vulnerable and rather precariously positioned. There were a number of important issues that needed attention to change the steadily declining state of agriculture by building resilience into the local farming systems. This would be possible IF appropriate climate-smart processes were identified; and IF these were compiled as information packs that addressed farmers through effective knowledge sharing systems. IF the national policy was more effectively institutionalised at provincial and municipal levels; and IF this was supported by budgets earmarked to implement climate risk adaptation processes, then it could be concluded from the findings of the study that conditions were still well-suited to crop and livestock farming enterprises. The farmers would eagerly participate in adaptation processes, IF they promised to build resilience to climate risk and create more opportunities to stabilise or increase productivity, and improve food security.

Figure 5.1: A proud farmer surveys his post-emergence maize crop near Weltevrede, 2014. Sadly he no longer plants crops here because of theft and marauding animals (Source: personal collection).

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**APPENDIX A: INTERVIEW GUIDE A**

# SEMI-STRUCTURED INTERVIEW GUIDE (A) FOR FARMERS

These questions are designed to act as a guide to the semi-structured interview sessions to be held with farmers who have experience and insights into the agricultural sector of the Mooifontein Region, Ngaka Modiri Molema in the North West Province. Participants are at all times invited to express their own experiences and insights during the interview process.

Researcher: Jennifer Ann Mathews
University: North-West University
Student No: 244808185

Dear Participant
Thank you for being willing to participate in this research. Your valuable contribution towards this body of knowledge is appreciated.

Your insights will contribute to my dissertation for a Masters in Development and Management Studies at the Potchefstroom campus of North-West University entitled:

***Building resilience to climate risk in the agricultural sector through adaptation education using a climate-smart approach: The case of the Mooifontein region, North West province***

## SECTION ONE: GENERAL INFORMATION

**The field of study:**

Mooifontein is the hub of a farming region covering approximately 10 000ha that includes the villages of Brooksby, Mooifontein, Lombaardslaagte, Deelpan, Enselrus, Weltevrede and Uitkyk. Each of the settlements is surrounded by arable lands and areas of commonage used primarily for grazing livestock.

**Objectives of this study:**

This research project is an investigation into the degree of awareness of climate change 1) as a phenomenon and 2) as a risk to farming in the Mooifontein region of the North West province. The researcher aims to establish whether or not agriculturalists in the region of study have experienced climate change as a stress factor. The objective is to learn more about local insights into climate-smart farming and to identify whether any forms of adaptation and mitigation of the risks to sustainable farming have been implemented. Further to this, the researcher also aims to identify the paths of knowledge sharing amongst the farming community including farmers and agricultural specialists.

**Importance of the study**

This study could pave the way for more effective region-specific development and interventions which will contribute to climate risk management in the Mooifontein agricultural sector. The recommendations are intended to contribute to farmer development and sustainable farming solutions.

**Participant privacy**

Please note that you are voluntarily participating in this study and all your responses will be treated on a strictly private and confidential basis.

**INSTRUCTIONS**

- Please be aware that all your responses are valued.
- There is no right or wrong answer.
- Please feel free to respond with your own insights that the interviewer will note down.
- **Please note all questions allude specifically to the field of study i.e. Mooifontein region.**

## SECTION TWO: BACKGROUND INFORMATION

**2.1.1 Please provide the following information about yourself:**

2.1.2 Gender

| MALE | FEMALE |
|---|---|

2.1.3 Age

| 20-30 | 30-40 | 40-50 | 50-60 | 60-70 | 70+ |
|---|---|---|---|---|---|

2.1.4 Closest Village

| Brooksby | Deelpan | Enselrus | Lombaardslaagte | Mooifontein | Uitkyk | Weltevrede |
|---|---|---|---|---|---|---|

2.1.5 Number of years farming

| 0-5 | 6-10 | 11-20 | 21-30 | 31-40 | 41-50 | 51+ |
|---|---|---|---|---|---|---|

**2.2 Please provide the following information about your farming activities:**

2.2.1 How many hectares of land do you farm?

| 0-15 | 16-50 | 51-100 | 101-300 | 300+ |
|---|---|---|---|---|

2.2.2 How do you gain access to land?

| Access to land | How many hectares of each? |
|---|---|
| Owned (title deed is held) | |
| Land reform Beneficiary (Government lease/ Purchase agreement/ LRAD/ PLAS) | |
| Rented land | |
| Communal land | |

2.2.3 What crops do you grow? How many hectares of each crop do you plan to plant in the coming 2016/2017 season?

| Crop | Hectares |
|---|---|
| Maize | |
| Sunflowers | |
| Beans | |
| Groundnuts | |
| Grain Sorghum | |
| Other | |

2.2.4 What form of tillage do you practise?

| | |
|---|---|
| A. Conventional ploughing (e.g. mouldboard or disc ploughs) | |
| B. Conservation tillage – no ploughing/ tine implement (e.g. Vibroflex) | |
| C. No- Till – no mechanical intervention (plant and spray only) | |

2.2.5 Do you ever fallow your lands?

| YES | NO |
|---|---|

2.2.6 What type of weed control measures do you practice?

| | |
|---|---|
| A. Chemical weed control - Total cover | |
| B. Chemical weed control - Spraying on the row | |
| C. Mechanical weed control – mechanical cultivation/ hand hoeing | |
| D. All of the above | |

2.2.7 Do you have livestock or poultry? Please supply numbers where applicable.

| **Livestock** | **Numbers** |
|---|---|
| Cattle | |
| Goats | |
| Sheep | |
| Pigs | |
| Poultry | |
| Other | |

## SECTION THREE

### 3.1 CLIMATE CHANGE AND OTHER RISKS FOR SUSTAINABLE FARMING:

3.1.1 What does the term “climate change” mean to you? Probe: If no response, ask about “global warming”.

3.1.2 Do you think there has been a change in the weather patterns, and if so what changes have you observed? Probe if affirmative: How long ago do you think changes began?

3.1.3 What changes in rainfall and temperature, over the last 15 years, have you observed?

3.1.4 Do you think that drought conditions are occurring more frequently? Explain.

3.1.5 What do you think the future for maize cropping in this region looks like? Probe: What other crops could you possibly plant with success in this region?

3.1.6 What do you think the future for livestock farming in this region looks like? Probe: How do you feel about the communal grazing system?

3.1.7 Describe your biggest challenges for your crop farming this year?

3.1.8 Have you thought about how the changes in climate are affecting your farming business? Probe: Do you think it is a serious problem already?

## 3.2 CLIMATE-SMART AGRICULTURE AND SUSTAINABLE FARMING

3.2.1 Have you heard of ‘climate-smart agriculture’ before?

3.2.2 What do you think “climate smart farming” (CSA) is all about?
Probe: Do you think there is room for CSA in this region?
Probe: Do you think there are opportunities to make changes in your farming?
Probe: Can you afford to risk trying new things?

3.2.3 Would you say that farmers have already been changing their farming practices?

3.2.4 Have you made any changes to the way you farm in the last 5 years?

3.2.5 Do you think that effective climate-smart farming practices already exist in the Mooifontein?

3.2.6 What changes have you made to your farming practices? Probe: What convinced you to make these changes? Probe: Have these changes been worthwhile?

3.2.7 Risk perception index: How would you personally evaluate the following as risks to sustainable farming in the Mooifontein region?

| | **How great a risk is the following:** | **Not at all** | **Low risk** | **Medium Risk** | **High Risk** | **Highest risk** |
|---|---|---|---|---|---|---|
| 1. | The impacts of climate change | | | | | |
| 2. | The high cost of inputs | | | | | |
| 3. | Accessibility to the market | | | | | |
| 4. | Drought | | | | | |
| 5. | The high cost of farm machinery and equipment | | | | | |
| 6. | Heat waves | | | | | |
| 7. | Lack of government support to farmers e.g. grants/ subsidised loans and interest rates/ poor extension officer support | | | | | |
| 8. | Finding feed for my livestock | | | | | |
| 9. | Accessing knowledge about new farming practices e.g. precision farming/ conservation agriculture/ climate-smart farming | | | | | |
| 10. | The stress of carry-over debt and the accompanying interest burden | | | | | |
| 11. | I don't know enough about the futures markets and don't get the best prices for my crops | | | | | |
| 12. | Profit margins keep shrinking | | | | | |
| 13. | I struggle to access crop insurance | | | | | |
| 14. | Political uncertainty | | | | | |
| 15. | A cash flow pinch | | | | | |

### 3.3 PERCEPTIONS OF DRR and KNOWLEDGE MANAGEMENT

3.3.1 Have you heard of the term “disaster risk management”?

3.3.2 What do you understand by the term “disaster risk management”?

3.3.3 Do you think that climate change is a hazard and a disaster risk in farming?

3.3.4 Do you think farmers should be shown how to farm in ways that will lower their risk to climate change?
Probe: Explain why you think this is important – or not important?

3.3.5 In your opinion, is enough being done about knowledge transfer to farmers regarding climate risk management? Give a reason for your answer?

3.3.6 Describe what forms of government intervention and support are given to farmers to create awareness about climate-smart farming?
Probe: How much direct contact do you have with government support services to agriculture?
Probe: How often do you have face-to-face contact with an agricultural extension officer?
Probe: Do you have any thoughts on the value-add to your farming from this service?

3.3.7 Where do you acquire knowledge about different aspects of farming? Mark your selected answers with an “X”?

3.3.9 Are you aware of farmer development initiatives in this region?

**4.** Do you have any other CONCERNS or OBSERVATIONS about your experience of climate change as a farmer in the Mooifontein region?

**APPENDIX B: INTERVIEW GUIDE B**

# SEMI-STRUCTURED INTERVIEW GUIDE (B) FOR AGRICULTURAL EXPERTS

These questions are designed to act as a guide to the semi-structured interview sessions to be held with farmers and agricultural specialists who have experience and insights into the agricultural sector of Mooifontein, Ngaka Modiri Molema in the North West Province. Participants are at all times invited to express their own experiences and insights during the interview process.

Researcher: Jennifer Ann Mathews
University: North-West University
Student No: 2448084

Dear Participant
Thank you for being willing to participate in this research. Your valuable contribution towards this body of knowledge is appreciated.

The information you provide will contribute to my dissertation for a Masters in Development and Management Studies at the Potchefstroom campus of North-West University entitled:

***Building resilience to climate risk in the agricultural sector through adaptation education using a climate-smart approach: The case of the Mooifontein region, North West province***

## SECTION ONE: GENERAL INFORMATION

**The field of study:**

Mooifontein is the hub of a farming region covering approximately 10 000ha that includes the villages of Brooksby, Mooifontein, Lombaardslaagte, Deelpan, Enselrus, Weltevrede and Uitkyk. Each of the settlements is surrounded by arable lands and areas of commonage used primarily for grazing livestock.

**Objectives of this study:**

This research project is an investigation into the degree of awareness of climate change 1) as a phenomenon and 2) as a risk to farming in the Mooifontein region of the North West province. The researcher aims to establish whether or not agriculturalists in the region of study have experienced climate change as a stress factor. The objective is to learn more about local insights into climate-smart farming and to identify whether any forms of adaptation and mitigation of the risks to sustainable farming have been implemented. Further to this, the researcher also aims to identify the paths of knowledge sharing amongst the farming community including farmers and agricultural specialists.

**Importance of the study**

This study could pave the way for more effective region-specific development and interventions which will contribute to disaster risk management in the Mooifontein agricultural sector. The recommendations are intended to contribute to farmer development and sustainable farming solutions.

**Participant privacy**

Please note that you are voluntarily participating in this study and all your responses will be treated on a strictly private and confidential basis.

**INSTRUCTIONS**

- Please be aware that all your responses are valued.
- There is no right or wrong answer.
- Please feel free to respond with your own insights that the interviewer will note down.
- **Please note all questions allude specifically to the field of study i.e. Mooifontein region.**

## SECTION TWO: BACKGROUND INFORMATION

Please provide the following information about yourself:

1. Gender:

| MALE | FEMALE |
|---|---|

2. Age:

| 20-30 | 30-40 | 40-50 | 50-60 | 60-70 | 70+ |
|---|---|---|---|---|---|

3. Field of expertise/qualification _____

4. Where do you work? _____

## SECTION THREE

### 3.1 CLIMATE CHANGE AND OTHER RISKS FOR SUSTAINABLE FARMING

3.1.1 What are your thoughts about the theory of climate change?

3.1.2 Do you think climate has changed? Please elaborate on this.

3.1.3 What changes have you observed in rainfall and temperature, over the last 15 years?

3.1.4 Do you think that drought conditions are occurring more frequently? Explain.

3.1.5 What do you think the future for maize cropping in this region looks like?

3.1.6 What do you think of the state of the rangelands in the region? Elaborate on how this impacts livestock farming opportunities here.

3.1.7 In your opinion, do you think that changing climate is affecting farming businesses and how?

### 3.2 CLIMATE-SMART AGRICULTURE AND SUSTAINABLE FARMING

3.2.1 What do you understand by the term “climate-smart” agriculture?

3.2.2 Do you think that effective climate-smart farming practices already exist and have they been effective?

3.2.3 Do you think there is room for CSA in this region?

3.2.4 Tell me about FIVE farming system adaptations you have found to be successful here?

3.2.5 Have these changes been motivated by the impact of climate change? If not then what other impetus lies behind the adaptation?

3.2.6 Risk perception index: How would you personally evaluate the following as

| | **How great a risk is the following:** | **Not at all** | **Low risk** | **Medium Risk** | **High Risk** | **Highest risk** |
|---|---|---|---|---|---|---|
| 1. | The impacts of climate change | | | | | |
| 2. | The high cost of inputs | | | | | |
| 3. | Accessibility to the market | | | | | |
| 4. | Drought | | | | | |
| 5. | The high cost of farm machinery and equipment | | | | | |
| 6. | Heat waves | | | | | |
| 7. | Lack of government support to farmers e.g. grants/ subsidised loans and interest rates/ poor extension officer support | | | | | |
| 8. | Finding feed for my livestock | | | | | |
| 9. | Accessing knowledge about new farming practices e.g. precision farming/ conservation agriculture/ climate-smart farming | | | | | |
| 10. | The stress of carry-over debt and the accompanying interest burden | | | | | |
| 11. | I don't know enough about the futures markets and don't get the best prices for my crops | | | | | |
| 12. | Profit margins keep shrinking | | | | | |
| 13. | I struggle to access crop insurance | | | | | |
| 14. | Political uncertainty | | | | | |
| 15. | A cash flow pinch | | | | | |

### 3.3 PERCEPTIONS OF DRR and KNOWLEDGE MANAGEMENT

3.3.1 What do you understand by “disaster risk management”?

3.3.2 Describe your view of climate change as a hazard and a disaster risk for farming?

3.3.3 How do you feel about the research being done into climate-smart practices at a regional level in the North West province?

3.3.4 How effective are extension officers and development agents being, as far as knowledge transfer to farmers regarding climate-smart farming is concerned?

3.3.6 What do you consider to be the most common barrier to any farmer adapting to climate-smart practices: **education, economics or equipment**. Please elaborate.

3.3.7 Are you aware of local farmer development initiatives? Please name them.

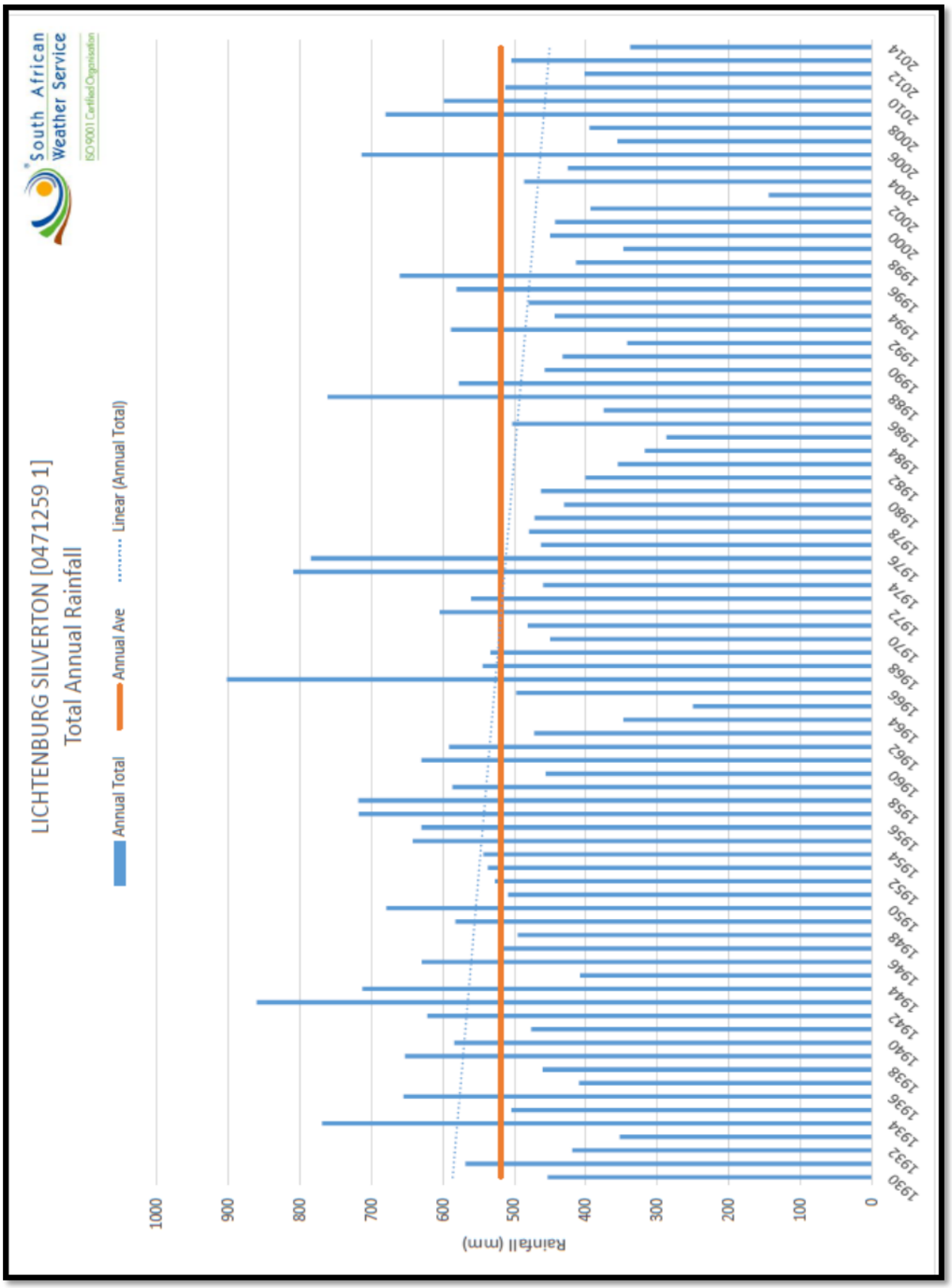
3.3.8 What, in your experience, is the most effective method of communicating important information to farmers?

3.3.5 List 5 important recommendations you would give to farmers, in the light of adapting to cope with climate change, using climate-smart farming methods?

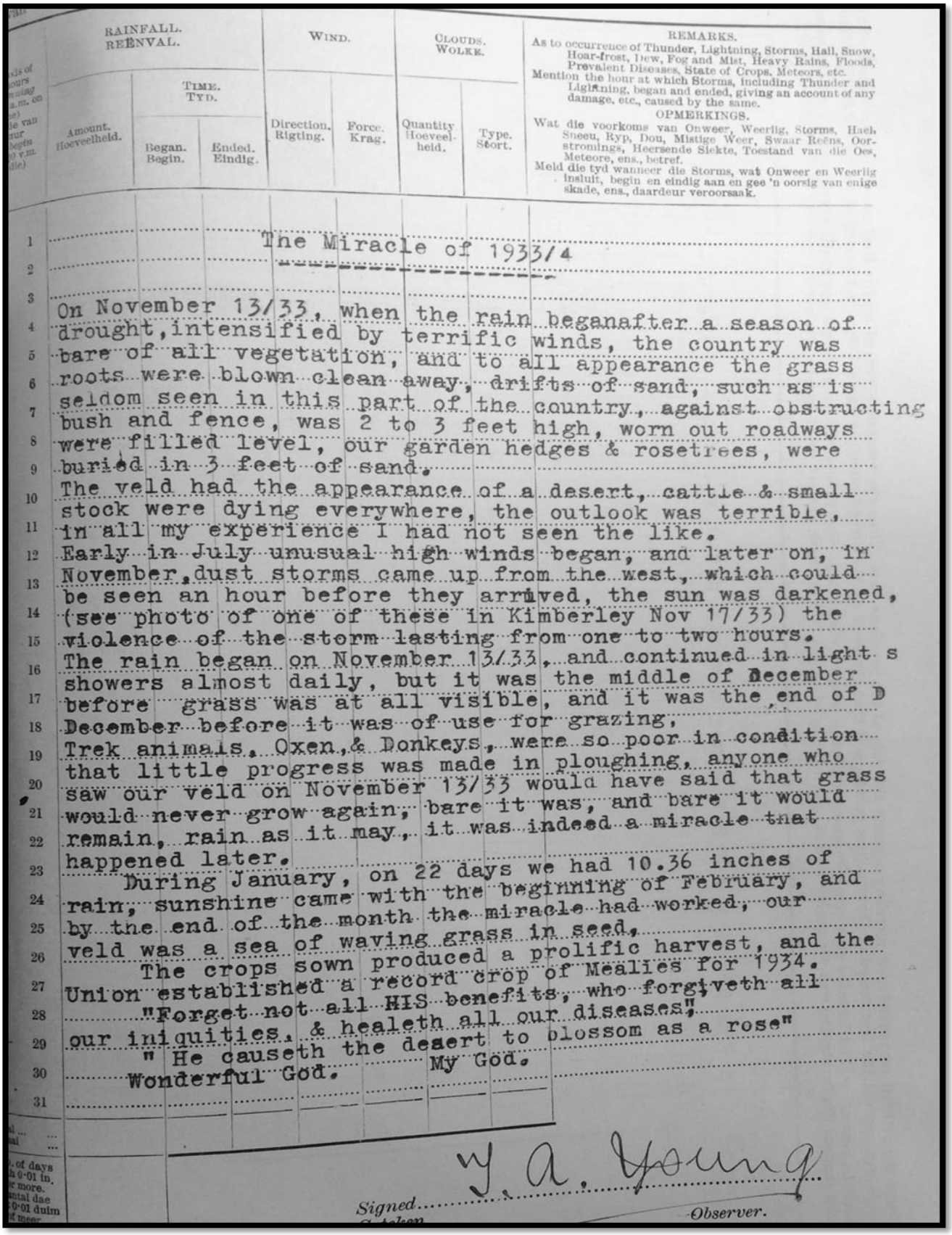
4. Do you have any other CONCERNS or OBSERVATIONS about your insights into the sustainability of farming in the face of climate change in the Mooifontein region?

## APPENDIX C: TOTAL ANNUAL RAINFALL

Analysis of official SAWS rainfall records for rainfall recording station: Lichtenburg Silverton [0471259 1], July 1929 - September 1916. (Source: SAWS, 2016)



## APPENDIX D: THE MIRACLE OF 1933/4



RAINFALL. REËNVAL. | WIND. | CLOUDS. WOLKE. | REMARKS.

Amount. Hoeveelheid. | Time. Tyd. Began. Begin. Ended. Eindig. | Direction. Rigting. | Force. Krag. | Quantity Hoeveelheid. | Type. Stort.

As to occurrence of Thunder, Lightning, Storms, Hail, Snow, Hoar-frost, Dew, Fog and Mist, Heavy Rains, Floods, Prevalent Diseases, State of Crops, Meteors, etc.
Mention the hour at which Storms, including Thunder and Lightning, began and ended, giving an account of any damage, etc., caused by the same.

OPMERKINGS.

Wat die voorkoms van Onweer, Weerlig, Storms, Hael, Sneeu, Ryp, Dou, Mistige Weer, Swaar Reëns, Oorstromings, Heersende Siekte, Toestand van die Oes, Meteore, ens., betref.
Meld die tyd wanneer die Storms, wat Onweer en Weerlig insluit, begin en eindig aan en gee 'n oorsig van enige skade, ens., daardeur veroorsaak.

The Miracle of 1933/4

On November 13/33, when the rain beganafter a season of drought,intensified by terrific winds, the country was bare of all vegetation, and to all appearance the grass roots were blown clean away, drifts of sand, such as is seldom seen in this part of the country, against obstructing bush and fence, was 2 to 3 feet high, worn out roadways were filled level, our garden hedges & rosetrees, were buried in 3 feet of sand.
The veld had the appearance of a desert, cattle & small stock were dying everywhere, the outlook was terrible, in all my experience I had not seen the like.
Early in July unusual high winds began, and later on, in November,dust storms came up from the west, which could be seen an hour before they arrived, the sun was darkened, (see photo of one of these in Kimberley Nov 17/33) the violence of the storm lasting from one to two hours.
The rain began on November 13/33, and continued in light s showers almost daily, but it was the middle of December before grass was at all visible, and it was the end of D December before it was of use for grazing,
Trek animals, Oxen,& Donkeys, were so poor in condition that little progress was made in ploughing, anyone who saw our veld on November 13/33 would have said that grass would never grow again, bare it was, and bare it would remain, rain as it may, it was indeed a miracle that happened later.
During January, on 22 days we had 10.36 inches of rain, sunshine came with the beginning of February, and by the end of the month the miracle had worked, our veld was a sea of waving grass in seed.
The crops sown produced a prolific harvest, and the Union established a record crop of Mealies for 1934.
"Forget not all HIS benefits, who forgiveth all our iniquities, & healeth all our diseases"
" He causeth the desert to blossom as a rose"
Wonderful God. My God.

W. A. Young

Signed..... Observer.

(Source: Private collection of Rainfall records, Mathews Family, Silverton Farm)

## APPENDIX E: BACK GROUND OF FARMER PARTICIPANTS

### Interview Guide A: Section 2, summarised

| Description | Age | Gender | Years farming | Access to land | Hectares planted | Summer crop 2016-2017 | Tillage practices | Fallow lands | Weed control | Livestock | Researcher field notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Farmer #1 | 60-70 | F | 21-30 | Own 15ha /Rent/Communal | 51-100 | 65 ha sunflowers | Conventional ploughing; some no till | no | Total cover weed control; hand hoeing | 5 cows/ 30 sheep/ 15 hens | No longer plants maize (theft, animals); lost animals in the drought – no food; Had a grant for 2015/16 |
| Farmer #2 | 60-70 | F | 11-20 | Own 15ha/ Rent/ Communal | 101-300 | 60 ha Maize; 225 ha sunflowers | Conventional ploughing; some minimum till (ripper) | yes | Total cover; hand hoe | 15 cows/ 40 sheep/ 640 hens (egg production) | Theft of crops is a growing problem – even sunflowers |
| Farmer #3 | 40-50 | M | 11-20 | Rent; communal | 300+ | 0 Maize (theft) – 310 sunflowers/ 15 ha soybean | Plough but moving to conservation tillage | no | Total cover; no cultivators | 24 cows, 2 bulls, 8 calves/ 15 goats/ 12 sheep/ 300 broilers/ 200 layers | Theft is a big problem; Government grants have helped but are not reliable |

| Description | Age | Gender | Years farming | Access to land | Hectares planted | Summer crop 2016-2017 | Tillage practices | Fallow lands | Weed control | Livestock | Researcher field notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Farmer #4 | 30-40 | M | 6-10 | Own; rented | 300+ | 880 maize; 800 sunflowers; 200 fallow | Rip – minimum till | Yes | Total cover; some cultivation | 0 | Very progressive, used technology as much as possible – focused on soil moisture conservation |
| Farmer #5 | 20-30 | M | 0-5 | Own/ rented | 300+ | 120 pastures; 25 cover crops; 200 fallow | Vibroflex - minimum | yes | Total cover | 60 cows and calves; 40 stud cows + 20 calves; 3 bulls | Livestock: main focus – doesn't like the risk of crop farming. Stud animals increase value per unit. Using modern technologies. |
| Farmer #6 | 40-50 | M | 11-20 | LRAD farm | 100-300 | 160 sunflowers; 55 pastures | Ploughs (kweekgras); ripper (needs a bigger one) | No – can't afford to | Total cover; cultivators where needed | 50 cows; 25 goats; 50 ewes – 35 lambs; | Wouldn't farm if it wasn't private land – villages are a problem – disillusioned. We have to help ourselves – work hard – pay off all debts |

| Description | Age | Gender | Years farming | Access to land | Hectares planted | Summer crop 2016-2017 | Tillage practices | Fallow lands | Weed control | Livestock | Researcher field notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Farmer #7 | 70+ | M | 21-30 | LRAD farm | 100-300 | 120 maize | Ploughs (kweekgras); ripper (needs a bigger one) | No – can't afford to | Total cover; cultivators where needed | 53 cows; 60 ewes = 47 lambs; 56 hens; 3 horses (herd cattle out of fields) | Used to farm around village – donkeys/theft/cattle raid crops/ no fences/ too many fights |
| Farmer #8 | 50-60 | M | 31-40 | Own/rent | 300+ | 1000 ha sunflowers/ 50 ha sugar beans/ 50 ha soybean | No-till only | Yes | Total cover | 21 blesbok | Very progressive – focuses on big machinery to do more using less labour and fuel – Full on no-till – a learning curve – Maize not viable now |
| Farmer #9 | 60-70 | M | 31-40 | Own/rent/communal | 100-300 | 230ha maize/ 600 sunflowers | Plough (but very costly) | No – I can't afford to | Total cover spray; very little cultivation | 200 cows + calves/ 400 ewes with lambs; household egg production | Disillusioned with communal system. Cattle destroy crops-villagers steal – not convinced that no-till works here |

## APPENDIX F: LANGUAGE EDITOR'S LETTER

DR MICHELLE COETZEE
(D.Phil.Theology - St Augustine's College, 2014)
AUTHORISED LANGUAGE PRACTITIONER
(English)
45A Collins St, Brixton, 2092, RSA • Tel+27 (0)11-830-0794 • Cell +27 (0)79-516-8067 • coetzee.michelle71@gmail.com

14 November 2016

Dear Jennifer Mathews

**Language editing**

This is to confirm that I edited your master's dissertation, *BUILDING RESILIENCE TO CLIMATE RISK IN THE AGRICULTURAL SECTOR THROUGH ADAPTATION EDUCATION USING A CLIMATE-SMART APPROACH: THE CASE OF THE MOOIFONTEIN REGION, NORTH WEST PROVINCE*, and that I indicated the necessary grammatical corrections.

Although I took all reasonable precautions to ensure that all grammatical and stylistic corrections are indicated, you remain responsible for the final product. Therefore, please check these suggested corrections before applying them and, if possible, again perform a spell check after you have implemented them, in order to eliminate typing errors.

Please contact me if there are any queries or if I can be of further assistance.

Yours sincerely

Michelle Coetzee