Insights into Indigenous Coping Strategies to Drought for Adaptation in Agriculture: A Karoo Scenario

Report to the
Water Research Commission

by

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EXECUTIVE SUMMARY

BACKGROUND

There is a gap in understanding and recognizing the value of indigenous knowledge in reducing vulnerability of rural communities to impacts of hazards such as drought. Local people who are most vulnerable to these impacts are left out of the research in many studies. It has been proved by many recent studies that local or indigenous knowledge holds valid, meaningful and relevant answers for coping with current and future droughts. Studies capturing local indigenous knowledge of the impacts, experiences, coping and adaptation strategies (or risk management strategies) of past and current droughts in South Africa are lacking, although indigenous people such as the Khoisan have been living and coping with extreme environmental conditions such as drought for a long time. The project sought to document and capture indigenous coping and adaptation practices of farmers in the Karoo to limit further loss of this valuable knowledge through limited intergenerational transfer or colonization by mainstream modern scientific knowledge.

AIMS

The following were the aims of the project:

- Review international and South African literature on capturing indigenous knowledge around the experiences of drought in agriculture and its value for informing future planning.
- Identify and capture any coping strategies (indigenous knowledge) adopted by communities working in the agricultural sector for dealing with the 2009/10 drought and past drought experiences.
- Identify measures that would ensure the resilience of the agricultural sector to future droughts through upscaling good indigenous practices into drought preparedness planning.

METHODOLOGY

A detailed desktop review of indigenous knowledge was carried out and case studies from all over the world were documented. The Intergovernmental Panel on Climate Change (IPCC) list of adaptation and action strategies for agriculture was also presented. The selection of farmers for the study was undertaken in collaboration with extension officers and project advisers. Methods for capturing indigenous knowledge were also reviewed and appropriate methods were selected for the study. Participatory research methods were adopted for the whole study, particularly in interactions with the famers. Semi-structured interviews and meetings were conducted with District Extension Managers, field based extension and Landcare officers. Three methods were selected for collecting data from the farmers, viz semi-structured interviews, focus group discussions and field observations.

RESULTS AND DISCUSSION

A wide ranging list of drought indicators was compiled from interviews with the farmers. Farmers understood well how the behaviour of certain animals and plants meant that drought was approaching. Wind direction, and changes in temperature were some of the signs used by the farmers. The signs were consistent with indigenous knowledge signs collected from other regions of Africa although the plant and animal species were different.

The research attempted to develop various typologies for assessing indigenous knowledge in the Karoo. The most appropriate method was found to be the one using farming systems of crop, mixed crop-livestock and livestock systems. The IPCC approach of presenting the data in form of impacts, coping and adaptation strategies was adopted. Corresponding scientific methods were also presented.

Crop systems consisted of horticultural farms. Farmers had devised methods of conserving moisture such as using bottles to moisten the soil slowly, mulching and shade netting. They used manure and household (kitchen) garbage to improve soil fertility.

Mixed crop-livestock systems had developed many coping mechanisms and the farmers had also developed adaptation strategies that ensured the systems kept operating even during severe drought. Fruit orchards were saved by reducing irrigation levels, and changing to cultivation of high value horticultural crops. Some farmers focused on single enterprises to keep the farms in operation. Other farmers had adapted by changing their systems from cropping to more drought-resistant livestock only systems.

Livestock farmers were the most resilient to drought. Some of the strategies adopted by the farmers dated back centuries. Migration with animals to better grazing lands was one of the oldest coping mechanisms used by livestock farmers. Farmers also purchased lucerne from other farmers or far off areas to feed their animals. Conserving grazing lands through long term paddocking and rotating camps was also another long term strategy used. Some farmers also resorted to early marketing of livestock, destocking and leaving the breeding herd intact and also manipulating feeding strategies to conserve the herd. Long term strategies included breeding for survival during drought, changing breeds, e.g. from Boer goats to more drought-resistant Angora goats, and changing systems to low input ostrich or game farming. Livestock farmers also developed methods of conserving water through rainwater harvesting from mountain slopes, construction of stock dams for water storage and use of windmill pumped boreholes. Building silt traps/sluits to prevent dam siltation and the construction of contours across slopes to conserve soil were other long term strategies.

The identified coping and adaptation strategies adopted by farmers in the Karoo indicate systems that have evolved over a long period of time. Some traditional methods have now been replaced with modern, more efficient methods, for example, flood irrigation has been replaced with water conserving drip irrigation. Although science has provided new methods of predicting weather, farmers still use their own traditional methods concurrently with modern methods. Farmers also continue to use century old methods grazing of management, soil and water conservation. Recent scientific methods are also used in conjunction with traditional methods. There is need to integrate these systems to increase farmer resilience to drought in the Karoo.

GENERAL

The first objective of the research was to review international and South African literature on indigenous knowledge around the experiences of drought in agriculture and its value for informing future planning. This objective was fulfilled. The second objective was to identify and capture any coping strategies (indigenous knowledge) adopted by communities in the agricultural sector for dealing with the 2009/10 drought and past drought experiences. This objective was also fulfilled and the results were shared with stakeholders who confirmed that the information was valuable. The third and final objective was to identify measures that would ensure the resilience of the agricultural sector to future droughts through upscaling good indigenous practices into drought preparedness planning. This objective was partly fulfilled. Not enough data were collected for use in the initially suggested frameworks for assessing livelihoods due to the complex nature of data collection. The project focused on the indigenous knowledge insights rather than of data on assets, natural resources and social data collection required in the frameworks. There is scope to collect the information in the next phase of the research.

CONCLUSIONS

There are unique farmers in the Karoo who do not necessarily fit the definitions of subsistence, smallholder and commercial farmer. Classifying the farmers according to systems and activities allowed easy documentation of indigenous knowledge, and the use of impacts, coping and adaptation also made clustering of the information easy. There is a rich knowledge base of indigenous local knowledge in the

Karoo that needs to be shared with the farmers and other relevant stakeholders. There is also need to find mechanisms of using this knowledge to improve farmer resilience to drought and increase their adaptive capacity.

RECOMMENDATIONS

The following are the final recommendations of the project:

- There is need to package the information and share it with other farmers in the Karoo and around South Africa. A policy brief for central and provincial government is also recommended
- Developing mechanisms for improving extension officer understanding of indigenous knowledge
- Improving farmer resilience in coping and adapting to drought in the Karoo needs to be further explored through research covering topics such as:
    - Long term early warning and accurate weather/climate forecasts
    - Planting more drought-resistant fodder plant species
    - Research on drought- resistant crops
    - Conservation agriculture
- Develop a more programmatic approach to support emerging farmers
- Collect more data/information from the Karoo for use in frameworks for assessing livelihoods
- Create linkages and more collaboration in research on farmer resilience to drought.

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ACRONYMS & ABBREVIATIONS

BGCMA	Breede-Gouritz Catchment Management Agency
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DoA	Department of Agriculture
DWS	Department of Water and Sanitation
IK	Indigenous knowledge
IKSP	Indigenous Knowledge Systems and Practices
IPCC	Intergovernmental Panel on Climate Change
ITK	Indigenous Technological Knowledge
IUCN	The International Union for Conservation of Nature
LAL	Learning about Livelihoods Framework
LIK	Local Indigenous Knowledge
PAR	Participatory action research
PRA	Participatory rural appraisal
RWH	Rainwater harvesting
SAWS	South African Weather Services
SL	Sustainable Livelihoods Framework
TEK	Traditional environmental knowledge
TK	Traditional knowledge
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
WRC	Water Research Commission

GLOSSARY*

Adaptation
The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.1

Adaptive capacity
The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.

Carrying Capacity
The population that can be supported indefinitely by its supporting systems. In ecological terms, the carrying capacity of an ecosystem is the size of the population that can be supported indefinitely upon the available resources and services of that ecosystem. (http://www.sustainablemeasures.com/)

Coping
The use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium term.

Coping capacity
The ability of people, organizations, and systems, using available skills, resources, and opportunities, to address, manage, and overcome adverse conditions.

Disaster
Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Drought
- Meteorological – a reduction in rainfall supply compared with a specified average condition, less than a certain amount (e.g. 70%).
- Agricultural drought – a reduction in water availability below the optimal level required by a crop during each different growth stage, resulting in impaired growth and reduced yields.
- Hydrological drought – the impact of a reduction in precipitation on natural and artificial surface and subsurface water resources.
- Socio economic drought – the impact of drought on human activities, including both direct and indirect impacts.

O'Farrell et al. (2009)

Hazard
The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Impacts
Effects on natural and human systems. In this report, the term ‘impacts’ is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change.

Indicator
Something that points to or shows something. In this document indictors of drought include signs, behaviours and appearances of the environment, vegetation and animal and animal behaviour.

Indigenous knowledge
Indigenous knowledge is the large body of knowledge and skills that has been developed outside the formal educational system. The knowledge is embedded in culture and is unique to a given location or society. It is the basis for decision-making of communities in food security, human and animal health, education and natural resource management (Guchteneire et al. (2001))

Large Stock Unit
A measure of the amount of animal biomass and grazing pressure that is being applied to the veld. One Large Stock Unit (LSU) is equivalent to a 450 kg steer gaining 500g per day. (Todd et al, 2009). A small stock unit (SSU) is defined as 15 % of a LSU (Herselman and Olivier (2010)).

Mitigation (of disaster risk and disaster)*
The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability.

Resilience
The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Vulnerability
The propensity or predisposition to be adversely affected.

*All definitions are from the Intergovernmental Panel on Climate Change report (2012) unless stated.

CHAPTER 1: BACKGROUND

1.1 INTRODUCTION

Limited water availability and poor soil fertility are the main factors limiting food production in the semi-arid areas of southern Africa (Beukes et al., 2008). Recurrent droughts, increasing production costs caused by the removal of subsidies on agricultural inputs have contributed to rural poverty and hunger in southern Africa (Kuntashula et al., 2008). The resource-poor rural households are the most affected by the resultant food insecurity and unemployment (van der Merwe and Beukes, 2008; Beukes et al., 2008). South African rural farmers are not an exception to these challenges.

The agricultural sector in South Africa only contributes 2.3 per cent to the national gross domestic product (GDP) (Department of Agriculture, Forestry and Fisheries (DAFF), 2010), but with its multipliers it is an important component of the South African economy contributing about 30 per cent of employment (Department of Environmental Affairs (DEA), 2010). The irrigation sector is the largest consumer of water (National Water Research Strategy (NWRS), 2004) accounting for about 62 per cent of water utilisation in South Africa, but also experiences water losses of between 30 and 40 per cent (Department of Water Affairs (DWA), 2004). Water is a finite resource and it is becoming increasingly scarce (DEA, 2010; Water Research Commission (WRC), 2009). Within the context of climate change, increased pressure is placed on South Africa's scarce water resource (DEA, 2010; Schulze, 2011). The typical climate of South Africa is considered to be semi-arid with average rainfall of 485 mm, just over 50% of the world average of 860 mm/annum (DWA, 2004). The distribution of rainfall varies significantly and the availability of water resources is very uneven (ibid). The Western part of the country tends to be the driest.

Drought is a normal, recurrent feature of South African climate (de Ronde et al., 1999; Rouault and Richard, 2003; Schulze et al., 2011a, The Water Wheel, 2007). The Western Cape Province has a history of recorded severe droughts from the 1920s (OneWorld Sustainable Investments, 2007) to the present where significant impacts were experienced in the agricultural sector. The country will continue to experience droughts and the likelihood of serious drought is greater with climate change (Monnik, 2002; Love et al., 2008; DEA, 2010).

In South Africa (and elsewhere) much attention to drought assessments and adaptation measures in agriculture is placed on scientific or engineering solutions (e.g. early warnings, soil moisture and rainfall data, hydrological modelling, dam management, drought-resistant crops) and institutional interventions (Schulze, 1984; Zucchini and Adamson, 1984; Dent et al., 1987; Hazelton et al., 1994; Mason et al., 1994; Stevens et al., 1998; de Ronde et al., 1999; Dube and Jury, 2003; Rouault and Richard, 2003; Tsheko, 2003; Spreeth et al., 2004; Gazendam and Oelofse, 2007; de Ronde and Spreeth, 2007). The reason for this emphasis can be attributed to the fact that the research and development agenda tends to be dominated by professionals with a scientific or engineering background where emphasis is placed on rainfall or soil moisture data and hydrological modelling (for drought studies), and modernization and mechanization of the agricultural sector. However, the most vulnerable people to the impacts of drought, the local or indigenous population, have been living and coping with extreme environmental conditions such as drought for a long time (Galloway McLean et al., 2009; Galloway McLean, 2010). Their local or indigenous knowledge therefore holds valid, meaningful and relevant answers for coping with current and future droughts, yet there have been limited studies capturing local indigenous knowledge of the impacts, coping and adaptation strategies adopted by rural communities in South Africa.

A growing body of knowledge has developed that highlights the value of traditional or indigenous or local knowledge for adapting to changing and extreme environments particularly in rural agricultural communities (e.g. Howes and Chambers, 1979; Roach, 1994; Batterbury and Forsyth, 1999; van Marrewijk, 2001; Kangalawe and Lyimo, 2008; Komwihangilo et al., 2008; Liwenga and Kangalawe, 2008; Manyatsi and Ndlela, 2008; Mwakalila, 2008; Galloway McLean et al., 2009; Galloway McLean, 2010; Mercer et al., 2010 etc). It is therefore critical to capture such indigenous adaptation practices before they are lost through limited intergenerational transfer (Speranza et al., 2009) or through colonization of mainstream modern scientific knowledge. Although there are many indigenous strategies for coping with multiple threats, climate variability and environmental change, indigenous strategies are insufficient to cope with the effects of climate change, nor are such strategies adequately supported by policy processes (Eriksen et al., 2008).

To ensure adequate adaptation measures it has for a long time been argued that scientific knowledge should incorporate indigenous knowledge and expertise (Howes and Chambers, 1979; Roach, 1994; SNC Agriculture, 2009 in Schulze, 2010). It is therefore critical that local indigenous drought coping strategies be documented for future generations. Against this background, a research project was developed. The study aimed at identifying and capturing current and past local coping and adaptation strategies and actions in the agricultural sector that may inform future drought adaptation and risk management strategies. In order to achieve the research aim three key objectives were developed.

1.2 PROJECT AIMS

The following were the aims of the project:

- Review international and South African literature on capturing indigenous knowledge around the experiences of drought in agriculture and its value for informing future planning.
- Identify and capture any coping strategies (indigenous knowledge) adopted by communities working in the agricultural sector in the Karoo region for dealing with the 2009/10 drought and past drought experiences.
- Identify measures that would ensure the resilience of the agricultural sector to future droughts through up scaling good indigenous practices into drought preparedness planning.

This work was carried out in the Karoo region of the Western Cape Province. The details of the site are outlined in Chapter 3 of this report.

1.3 SCOPE AND CONTEXT

The project originally had 6 deliverables which were revised to 7 owing to additional work that was carried out later in the project. This was necessitated by the need to carry out further site description. As a result the project was therefore extended. The original objectives of the project were focused on coping strategies in agriculture. However, when the actual data were collected the farmers also provided considerable adaptation information. The reference group therefore resolved that the data would be better presented if separation between coping and adaptation strategies was done. The project results therefore cover both types of strategies.

1.4 SUMMARY OF WORK

The project was completed. **Table 1.1** and **Table 1.2** summarise the work done and the dates of submission of the deliverables.

Table 1.1 Work completed

No.	Task	Summary of work
1	Review international and South African literature on capturing indigenous knowledge around the experiences of drought in agriculture and its value for informing future planning.	A comprehensive literature review was carried out. The review identified methods of capturing indigenous knowledge. A list of adaptation strategies and actions in agriculture was also presented in the review. Strategies adopted by farmers globally were also presented.
2	Identify and capture any coping strategies (indigenous knowledge) adopted by communities working in the Karoo agricultural sector for dealing with the 2009/10 drought and past drought experiences.	Field work was carried out with both extension officers and the farmers. Through interviews, focus group discussions, field observations and a comprehensive list of coping and adaptation strategies was compiled from farmers in the Karoo.
3	Identify measures that would ensure the resiliency of the agricultural sector to future droughts through up scaling good indigenous practices into drought preparedness planning.	Validation meetings and workshops were attended by extension officers and the Directorate in the Ministry of Agriculture. The meetings identified and discussed some of the strategies and methods that could be used to share the information gathered in the research project.

Table 1.2 Deliverables submitted

No.	Deliverable	Date Completed
1	Literature review on approaches in capturing indigenous knowledge in agricultural practices to inform adaptation against changing environments	15/12/2011
2	Annual Progress Report including selection and motivation for a research area and research group for indigenous knowledge in agriculture	15/02/2012
3	Report on the types of agriculture that the target population engages in and the water demand required	31/01/2013
4	Annual Progress Report and Report on Insights into Indigenous Farming practices in coping with droughts in the Southern Cape	15/03/2014
5	Report on measures for drought resilience in agriculture based on indigenous insights	30/10/2013
6	Report on measures for drought resilience in agriculture based on indigenous insights: Indigenous knowledge typologies, strategies and actions	28/02/2014
7	Final Integrated Research Report: Insights into Indigenous Coping Strategies for Drought Adaptation in Agriculture: A Karoo Scenario	28/02/2015

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The main objectives of the project were to capture local indigenous experiences of coping with agricultural drought in the Karoo. The case study covered three municipalities, Oudtshoorn, Prince Albert and Beaufort West. Parts of these municipalities experienced the worst droughts around the 1960s. The study was based on the hypothesis that:

"Indigenous farmers hold local knowledge and practices that may be effective for coping and adapting to drought conditions. However, both local indigenous knowledge and scientific knowledge should be incorporated for effective drought risk adaptation".

The overall aim of the study was to identify and capture current and past local coping and adaptation strategies and actions by the agricultural sector that may inform future drought adaptation and risk management strategies.

2.1.1 Objectives and Approach of the Review

The main objective of the report was to address the first aim of the overall research through a literature review. The literature review had three sections that included:

- Determining an appropriate methodology for capturing local indigenous knowledge, determining if frameworks for assessing livelihood strategies and integrating local indigenous and scientific knowledge existed.
- Documenting local indigenous drought adaptation strategies and actions in agriculture in order to present a taxonomy of types of local indigenous adaptation strategies and actions that may be identified (but not limited to) in the field and establishing the value of capturing local indigenous knowledge for adaptation. Determining if local indigenous adaptation measures complement modern measures.

The report contains six chapters and three sets of appendices where over 100 case study examples were presented around local indigenous coping strategies to drought in agriculture, the use of rainwater harvesting and irrigation technologies by small-scale farmers in semi-arid regions. Case study examples were drawn from across Africa, Asia and Latin America.

2.2 DEFINING INDIGENOUS KNOWLEDGE

Grenier (1998) defines indigenous knowledge as ' the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area.' Indigenous knowledge is the local knowledge that is unique to a culture or society. Indigenous knowledge is also known as local knowledge, folk knowledge, peoples' knowledge, traditional wisdom or traditional science. This knowledge is passed on from generation to generation, usually by word of mouth and cultural rituals, and has been the basis for agriculture, food preparation, health care, education, conservation and the wide range of other activities that sustain a society and its environment in many parts of the world for many centuries (Sumner, 2006). Guchteneire et al. (2001) define indigenous knowledge as traditional or local knowledge, that is embedded in the community and is unique to a given culture, location or society. The term refers to the large body of knowledge and skills (Indigenous Knowledge Systems and Practices (IKSP), Indigenous Technological Knowledge (ITK)) that has been developed outside the formal educational system, and that enables communities to survive. The terms local and indigenous knowledge can be used interchangeably. This is acceptable as the terms traditional knowledge (TK), indigenous knowledge (IK), traditional environmental knowledge (TEK), indigenous technical knowledge (ITK) and local knowledge (LK) generally refer to the long-standing traditions and practices of certain regional, indigenous or local communities (Acharya and Anshu, 2008).

Since indigenous knowledge is not static, but constantly evolving, Denison and Wotshela (2009) refer to a continuum from pure indigenous knowledge to modern knowledge. In the South African context a strict distinction between indigenous and non-indigenous was not found to be useful, but instead a distinction between *indigenous*, *indigenized* and *contemporary-scientific* was more appropriate. Indigenous knowledge therefore then refers to truly indigenous practices, which is very rare in the South African context. Indigenized knowledge refers to those indigenous practices brought from North African and Middle Eastern traders and herders (and even from European settlers) to southern Africa and adapted and "localized" by the local population. Contemporary-scientific knowledge refers to new technology and practices introduced in the past three to four decades. Although Denison and Wotshela (2009) argue that truly indigenous practices are rare in South Africa and that most of the local practices were introduced from "outside", it should be noted that "outsiders" settling in South Africa also adopted truly indigenous practices. Farrell et al. (2009), for example, illustrate how the European settlers adopted indigenous herding strategies to cope with drought in the arid regions of South Africa. Recently Alcock (2010) used an approach that covered traditional (indigenous) knowledge, weather folklore or social memory to collect indigenous weather knowledge for South Africa. The knowledge covers different ethnic groups in South Africa. There is also a chapter dedicated to Western weather beliefs in a South African context.

The distinction between indigenous, indigenized and contemporary-scientific is a noble effort. However, for the purpose of this research the term *local indigenous knowledge* (LIK) will be used as this term does not place explicit emphasis on "indigenous knowledge" by truly indigenous populations. This is a rare phenomenon in South Africa as noted above and may limit the subjects under study. The term *local indigenous* thus extends the potential subjects to include more than just truly indigenous farmers, but also to accommodate local farmers irrespective of ethnicity, as well as to include any locals in the farming enterprise (e.g. extension workers, farming co-operatives and businesses etc.). Further, the idea of indigenous farmers may be narrow if it does not include farmers of European descent, as some of them may have a 300-year tradition of farming in parts of South Africa. Finally, the term *local indigenous* also accommodates for rare instances where local farmers have adopted truly indigenous practices.

2.3 SUMMARY OF THE REVIEW FINDINGS

2.3.1 Methodology for Capturing Local Indigenous Knowledge

Conventional methods of capturing information such as questionnaires were found to be inappropriate for capturing local indigenous knowledge. The most ideal approach for capturing local indigenous knowledge can be derived from ethnographic approaches within anthropology (Howes and Chambers, 1979). Participatory approaches are widely used for capturing local indigenous knowledge. The review of local and international literature suggested various methods for capturing indigenous knowledge. Some of these methods include:

Questionnaires: the conventional methods of questionnaires are inappropriate for capturing local indigenous knowledge for a number of reasons. Questionnaires force the informants to make sense of the researcher's categories of meaning and therefore may damage the informants' meaning system. Language barriers can also be hindrance.

Ethnographic approaches that can be used for capturing local indigenous knowledge were also identified in the literature (Howes and Chambers, 1979). The problem with the methods is that they are time consuming and they were therefore not appropriate for the scale and level of this project.

Participant observation was one of the methods identified and it was concluded that this method would ideally enable a comprehensive description of local indigenous knowledge and practices. However, the length of time required to implement this method as well as the costs involved were considered as constraining factors.

Participatory rural appraisal (PRA), rapid rural appraisal (RRA) and participatory action research (PAR) methods are widely used for capturing local indigenous knowledge (e.g. Reij et al., 1997; Langill and Ndathi, 1998; Mwaura, 1998; Koster, 2000; Liwenga and Kangalawe, 2008; Kangalawe and Lyimo, 2008; Mwakalila, 2008; Rusike et al., 2008; Kiem et al., 2010; Mercer et al., 2010; UNEP, 2010). These methods may also employ more unconventional techniques for data collection (Babbie et al., 2001). Drawing from the work of Fals-Borda (1991), Babbie et al (2001: 327-8) highlight some of these data collection techniques:

- *Collective research techniques* – where participants meet periodically in public assemblies (camps, workshops or collective trips) and information is collected and systematized on a group basis, involving a variety of expressive activities which enrich the inquiry.
- *Critical recovery of history* – where data is collected by means of interviews, usually taking the form of witness accounts by older members of the community. The primary goal is that data and facts are discovered which correct, complement, or clarify official or academic accounts written with other class interests or biases in mind.

An appropriate methodology for capturing local indigenous knowledge would therefore involve:

- Semi-structured interviews with individuals;
- Focus group discussions that would incorporate interactive tools such as:
  - Historical matrix and ranking
  - Participatory mapping (specifically hands-on mapping) and transect walks
  - Venn diagrams
  - Problem trees
  - Risk management and capacities matrix
- Observations and participant observations where the opportunity arises.

2.3.2 Types of Local Indigenous Adaptation Strategies and Actions

The review found that within the context of adapting to drought in the agricultural sector, local indigenous farmers have incorporated several strategies with specific actions for adaptation. The United Nations Framework Convention on Climate Change (UNFCCC) identified 21 local indigenous strategies for adaptation to drought and 31 local indigenous adaptation actions to drought in agriculture. Local indigenous knowledge and practices for adaptation fit in either one of the broad categories of technological innovation, changes in land use practices or economic diversification as noted by Batterbury and Forsyth (1999). Table 2.1 shows the UNFCCC list of adaptation and strategies and actions.

Table 2.1 Adaptation strategies and actions to drought in agriculture (UNFCCC, 2014)

Adaptation strategies	Adaptation actions
1. Dissemination of knowledge and/or education 2. Improved farm-level infrastructure design 3. Vector control 4. Appropriate crop selection 5. Alternative cultivation methods 6. Post-harvest management 7. Pest control 8. Rainwater harvesting 9. Sustainable water management 10. Soil conservation 11. Natural resource management 12. Nutrient management 13. Livelihood diversification 14. Appropriate livestock selection 15. Appropriate poultry selection 16. Diet diversification 17. Disaster risk management 18. Improved housing design 19. Appropriate appliances 20. Land redistribution 21. Land reclamation	1. Afforestation/reforestation 2. Agroforestry 3. Animal pest control 4. Appropriate irrigation methods 5. Check dams 6. Crop processing 7. Disaster preparedness 8. Disaster rehabilitation 9. Drought-resilient crops 10. Early warning 11. Food processing and storage 12. Forest management 13. Harvesting of wild foods 14. Horticulture 15. Improved cropping systems 16. Indigenous forecasting 17. Integrated agriculture-aquaculture 18. Livestock breeding 19. Ponds 20. Promotion of handicrafts 21. Rangeland management 22. Seed priming 23. Seed selection and storage 24. Soil fertilization 25. Tanks 26. Temporary land redistribution 27. Vermicomposting 28. Water allocation 29. Weed control 30. Wells 31. Bunds/ridges/terraces.

A separate CD with an expanded literature review is attached to this report. The review includes 61 case studies that provide examples of all 31 types of adaptation actions for drought or aridity based on local indigenous knowledge or resources. Case studies were selected from Africa, Asia (South-East Asia and the Middle East), Australia and Latin America.

2.3.3 Frameworks for Assessing Livelihood Strategies

The concept of "sustainable livelihoods" is increasingly being adopted as a framework for supporting adaptations (Batterbury and Forsyth, 1999), particularly where adaptations draw from local indigenous knowledge. The framework is useful for the analysis of local indigenous adaptation strategies and actions. The Learning about Livelihoods (LAL) framework can be used to analyse both the micro and macro environments and the influence that they have on each other. Key trends can therefore be identified that show how households of different categories of well-being are moving towards greater resilience and livelihood sustainability or falling into increased vulnerability. The LAL framework also enables change over time, for example, seasonality and historical changes, to be brought into the analysis (de Satgé et al., 2002; de Satgé, 2004).

The research for this project proposed to use variations of both the SL and LAL frameworks to analyse the local indigenous adaptation strategies in the Karoo. However, as the research progressed it became clear that the frameworks could not be used in their entirety due to the complexity in data collection, but that the project would draw some elements from the frameworks and also focus more on a comparative analysis of the indigenous knowledge practices and determine those unique practices that could be integrated with scientific knowledge.

2.3.4 Integrating Indigenous and Scientific Knowledge

The literature review proposed using the process framework (as described by Mercer et al., 2010) to develop a framework for integrating indigenous and scientific knowledge to reduce the vulnerability of indigenous communities to environmental hazards. The aim of the framework is to enable local indigenous people to reach a consensus regarding ways to approach their vulnerability to environmental hazards without having to conform to the dominant culture. The desired outcomes of the process are to:

- reduce vulnerability to environmental hazards
- increase collaboration among stakeholders
- organize disaster risk reduction planning.

Participatory approaches were proposed as methods for collecting the data required to develop the framework. The methods would enable local people to develop and define their own methodologies, drawing on their own conclusions in a strategy that suits them (Louis, 2007). The farmers in the Karoo would have assessed drought risks and come up with adaptive responses that are suitable to their own conditions. The framework normally involves a partnership between the community, the researchers and relevant stakeholders to identify a viable strategy that reduces vulnerability to environmental hazards (Mercer et al., 2010). As already mentioned, the complexity in data collection and variability in farmers and farming systems did now allow data collection and analysis to go that far.

CHAPTER 3: SELECTION AND MOTIVATION FOR THE RESEARCH SITE

3.1 INTRODUCTION

The project focused on three municipalities within the Western Cape Province, Beaufort West and Prince Albert which lie within the dry Central Karoo District and Oudtshoorn which is in the Eden District. Oudtshoorn is wetter and lies in the outskirts within the Karoo's Macro Biogeographica region that includes the arid interior and arid coastal plains of the Northern West Coast and the plains of the Great Karoo. The Karoo region covers a huge area roughly 45% of the province and is home to about 6% of its people. Figure 3.1 shows the location of the three municipalities that cover the case study area.

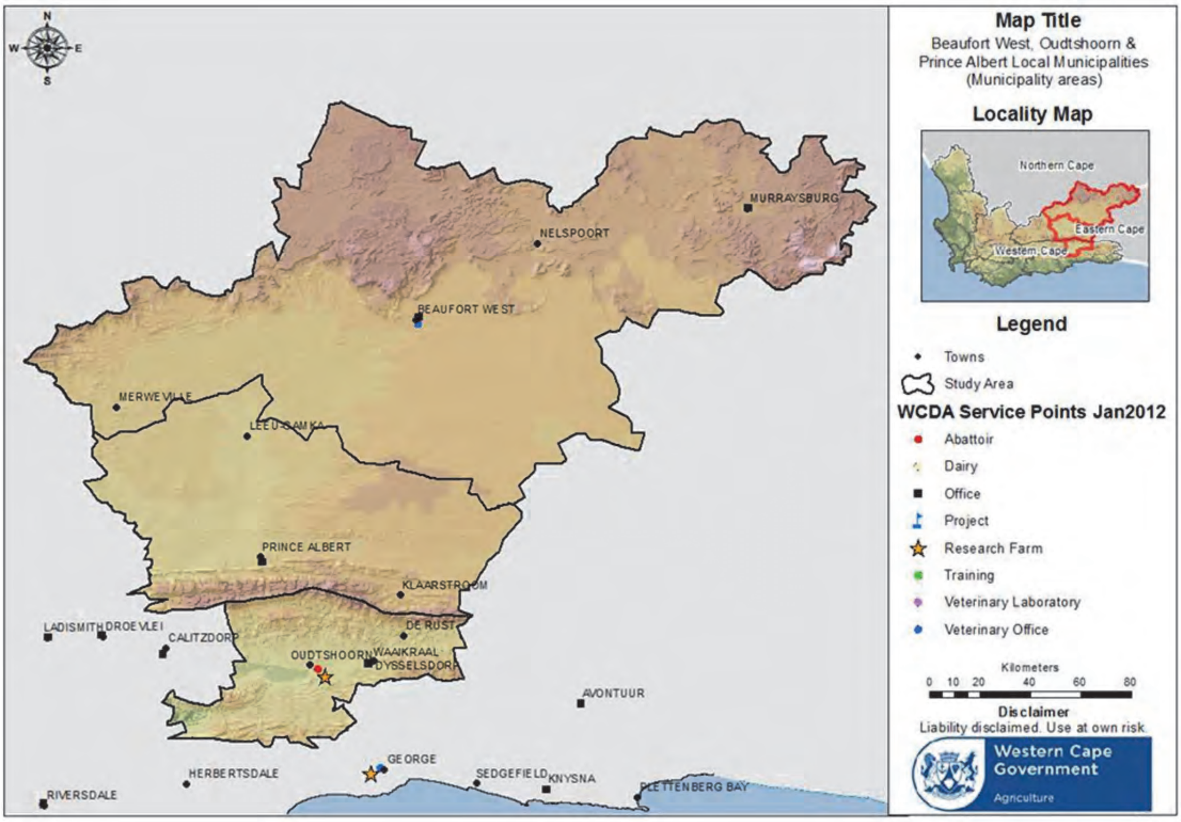

Figure 3.1 Location of Beaufort West, Prince Albert and Oudtshooorn Municipalities (Source: Western Cape Government Department of Agriculture GIS Unit)

The municipalities are serviced by a number of Agriculture and Landcare offices that are located within major towns. There is an agricultural research farm located at Oudtshoorn. There is also a Veterinary office in Beaufort West and an Abattoir in Oudtshoorn indicating the importance of livestock in the areas.

3.2 SELECTION OF THE STUDY SITE

A number of variables were considered in providing the guidelines for site selection of a case study area. These included the consideration of the climatological, environmental, social and economic phenomena.

3.2.1 Environmental Considerations

Disaster Risk Rating: The disaster risk rating indicated that during 2009-11 Beaufort West (in the Central Karoo District) was a high risk area, including two other municipalities in the Eden District (Knysna and Bitou). Oudtshoorn was rated as a medium risk area. However, feedback during the workshop clearly suggested that agriculture in the Karoo area was still problematic at the time of the debriefing in May 2011. Therefore the region between Beaufort West and Oudtshoorn (which includes portions of the Prince Albert Municipality) seemed appropriate for the research. The Post-Event Analysis Report (P.E.A.R) commissioned by Provincial Disaster Management Centre of the Western Cape also reported the impacts of the drought in the same region (Holloway et al., 2012). The preliminary discussions/findings of this report were also considered for site selection.

Climatological: Under this variable average rainfall was the main consideration. An area with the lowest rainfall would be the most ideal for the study. The case study area is characterised by irregular rainfall patterns. The average rainfall in Beaufort West area, for example, is estimated to be about 316.4mm (Holloway et al., 2012). During the 2008/2010 drought period, the average rainfall was 246mm for Beaufort West, 296mm for Oudtshoorn and 323mm for Prince Albert respectively. The low rainfall observed within the area was reported to have severely impacted on the farming activities.

Environmental: Elements considered under this variable were vegetation, water access and agricultural activities. The area under study is referred to as the Karoo. This region is described as semi-arid with an average annual rainfall of less than 350 mm. Water is especially a challenge in the Beaufort West and Oudtshoorn municipalities. Farmers rely heavily on borehole water. The intense agricultural activity in the area has further implications for predators (such as jackals) where food sources are diminishing due to receding natural habitat forcing them to prey on domestic sheep. With drought conditions, the natural vegetation in the area was stunted, reducing the food source and hence numbers of prey animals (rodents and reptiles), further forcing predator animals to feed on domesticated stock. Another area of concern is alien vegetation.

3.2.2 Population and Socio-economic Considerations

Socio-Economic Factors: This variable was considered because it influences the ability of people to resist or recover from a stress such as drought. It was therefore an important variable because it determines the extent of peoples' vulnerability to a drought. Basic socio-economic conditions were therefore reflected upon. The socio-economic characteristics of the municipalities under study are somewhat of a developmental concern. In the Beaufort West municipality education levels are not very high, health is not of a good quality and unemployment is high. High unemployment is a feature throughout the case study area. In the Prince Albert municipality for example, 62.7% of households are living below the minimum living level of poverty. In the Oudtshoorn municipality unemployment is also high with approximately 17.1% of the population unemployed.

Provincial Drought Debriefing: The Provincial Drought Debriefing, which focused on the 2009-11 droughts that affected the Eden and Central Karoo districts, was held on the 5th May 2011 in George. The purpose of this workshop was to bring closure to the drought management and to reflect on the lessons learnt. It was noted that the focus of the debriefing was primarily on water availability, water consumption and water demand management in the urban towns. The impacts of the drought on agriculture was not discussed in depth, but discussed superficially, thus showing a gap in the knowledge of drought impacts in this sector. Findings from this meeting confirmed that the Karoo was severely affected by drought. The drought within the area was characterised mainly by the scarcity of water which has implications on the farming activities.

Stakeholder Interviews: Stakeholder workshops, focus group meetings and household interviews were conducted and these were further considered in motivating for the case study area. Two focus group meetings were held with emerging farmers from Beaufort West and Oudtshoorn respectively. A stakeholder workshop with farmers from both areas including provincial and district government departments (Disaster Risk Management, Agriculture, Department of Water Affairs, Department of Rural Development and Land Reform) was conducted in January 2012. This stakeholder workshop mapped all the relevant role players who should be incorporated in the study and pointed the past drought, water scarcity, irregular rainfall patterns as key indicators of droughts. These indicators were used for the selection of the case study as well. Observations via a transect drive across the case study area were made to further motivate for the case study area. The transect drive was along the N12 starting from the Beaufort West Municipality, through the Prince Albert Municipality and concluding in the Oudtshoorn Municipality.

When physical and environmental factors were considered it was concluded that the areas around Beaufort West, Prince Albert and parts of Oudtshoorn were appropriate for the study because they had probably experienced drought more than other parts of the Western Cape Province. Socio-economic conditions and further discussions with local stakeholders also motivated for the same areas.

3.3 PHYSICAL CHARACTERISTICS

3.3.1 Geology and Soils

The Swartberg Mountains are part of the Cape fold mountain range that covers most of the Oudtshoorn Municipality. Although Oudtshoorn is in the Karoo, the soil is fertile because the Klein Karoo is an oasis-like setting in a fertile valley cupped by the Swartberg and Outeniqua mountain ranges, and it originated as a settlement along the Grobbelaars Rivers which meanders southwards from the Swartberg, providing fertile soil and water for irrigation. The Prince Albert and Whitehill Shales have until recently been almost universally regarded as part of a "Dwyka Series" whose main constituent was the Dwyka Tillite. The Prince Albert Shale is approximately 100 m of dark grey mudrock, while Whitehill Shale is black (white-weathering) thin-bedded carbonaceous shale plus subordinate thin layers or lenses of chert. The geology of Beaufort West mainly consists of Triassic Karoo sediments (sandstone, shale and mudstone) of the Beaufort Group that were intruded by Jurassic dolerites. The sediments are flat-lying, and the dolerite forms dykes and sills of variable thicknesses (10 to 100's of meters). Ground water in the area occurs in three geological environments, namely:

- Karoo sediments in the matrix
- Fractured-rock aquifers due to dolerite intrusions
- Granular aquifers due to quaternary deposit.

The quartzites of the Cape Supergroup generally give rise to soils that are acidic, nutrient-poor, coarse-grained, rocky and shallow as the dominant soil type on the Cape Mountains. Clay-rich and more fertile soils are limited and have developed from the shale’s of the Bokkeveld and Malmesbury Groups as well as from the Cape granites. Shallow, gravelly soils developed from patches of silcrete and ferricrete, which cap much of the Bokkeveld shale’s in parts of the region.. Soils in the valleys are predominantly shallow and stony, derived mainly from shale’s and conglomerates. They are clayey, fertile and alkaline (Griesel, 2004). Figure 3.2 shows soil potential classes in most of the area covered by the research site.

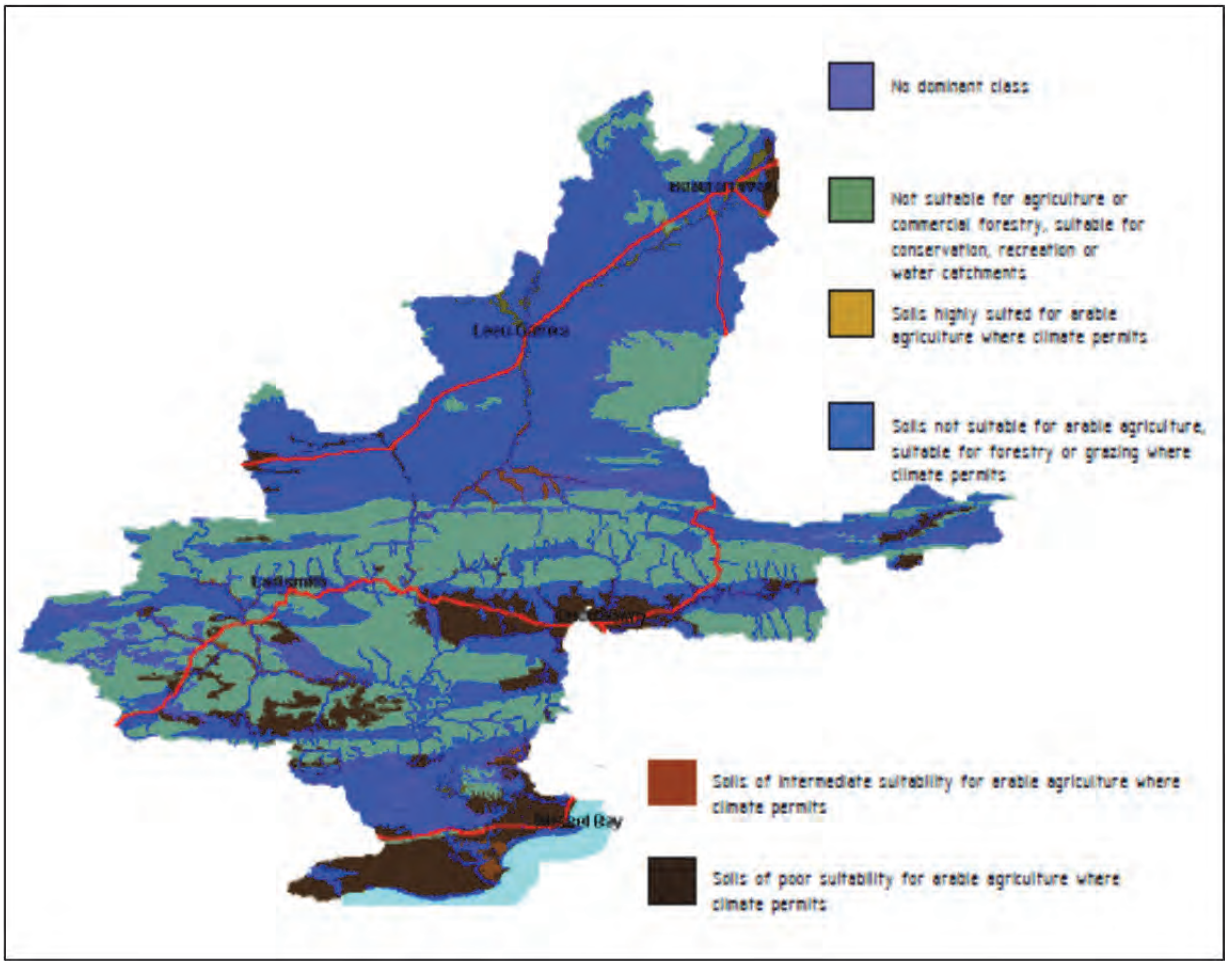

Figure 3.2 Soil Potential Classes (Source:Griessel, 2003)

3.3.2 Vegetation

The Karoo region is part of the Fynbos Biome which is mostly made up of two vegetation types (Renosterveld and Fynbos). Detailed descriptions of the Biomes of South Africa were published by Mucina and Rutherford in 2006. The Renosterveld is characterized by the dominance of members of the Daisy Family (*Asteraceae*), specifically one species – Renosterbos (Rhinoceros bush) *Elytropappus rhinocerotis,* from which the vegetation type gets its name. Grasses are also abundant in the veld. There is also a high species richness of bulb or geophytic plants (chiefly in theIris Family (*Iridaceae)* and Lily Family (*Liliaceae*), but also in the Orchid Family (*Orchidaceae*). The Renosterveld is confined to the fertile fine grained clays and silts that are derived from the Bokkeveld and Malmesbury Groups and the Karoo Sequence. Due to the high fertility most of the area has been converted to agriculture.

The other common vegetation type is the Fynbos which is made up of the restioid, ericod/heath and proteoid compoents. Fynbos is characterized by the presence of seven endemic or near-endemic plant families: Blacktips (*Bruniaceace*), Guyalone (*Geissolomaceae*), Sillyberry (*Grubbiaceae*) Brickleaf (*Penaeaceae*) Buttbush (*Retziaceae*), Dewstick (*Roridulaceae*) and Candlestick (*Stilbaceae*). Only the *Bruniaceae* (75 spp.), *Penaeaceae* (21 spp.) and *Stilbaceae* (13 spp.) comprise more than five species. The fifteen largest families comprise 70% of the species in the Fynbos Biome. Fynbos vegetation types occur predominantly on well-leached, infertile soils. The Fynbos vegetation types have low producivity due to the infertile soil; as a result they are little utilized for agriculture. The major use of Fynbos is for recreation, water catchment and exotic plantations. Under rainfall of less than 200mm Fynbos is replaced by Succulent Karoo. The vegetation is dominated by dwarf, succulent shrubs, of which the Vygies [ice-plants] (*Mesembryanthemaceae*) and Stonecrops (*Crassulaceae*) are particularly prominent. The area has little agricultural potential due to the lack of water. The paucity of grasses limits grazing and the low carrying capacity requires extensive supplementary feeds.

3.3.3 Mean Annual Temperature

Figure 3.3 shows the Mean Annual temperature distribution in the research site. Oudtshoorn is an area of climatic extremes, because of very cold winters, often with snow on the mountains and temperatures well below zero, while summers can be uncomfortably hot with temperatures reaching 40°C and more. It is generally hot in summer and mild in winter.

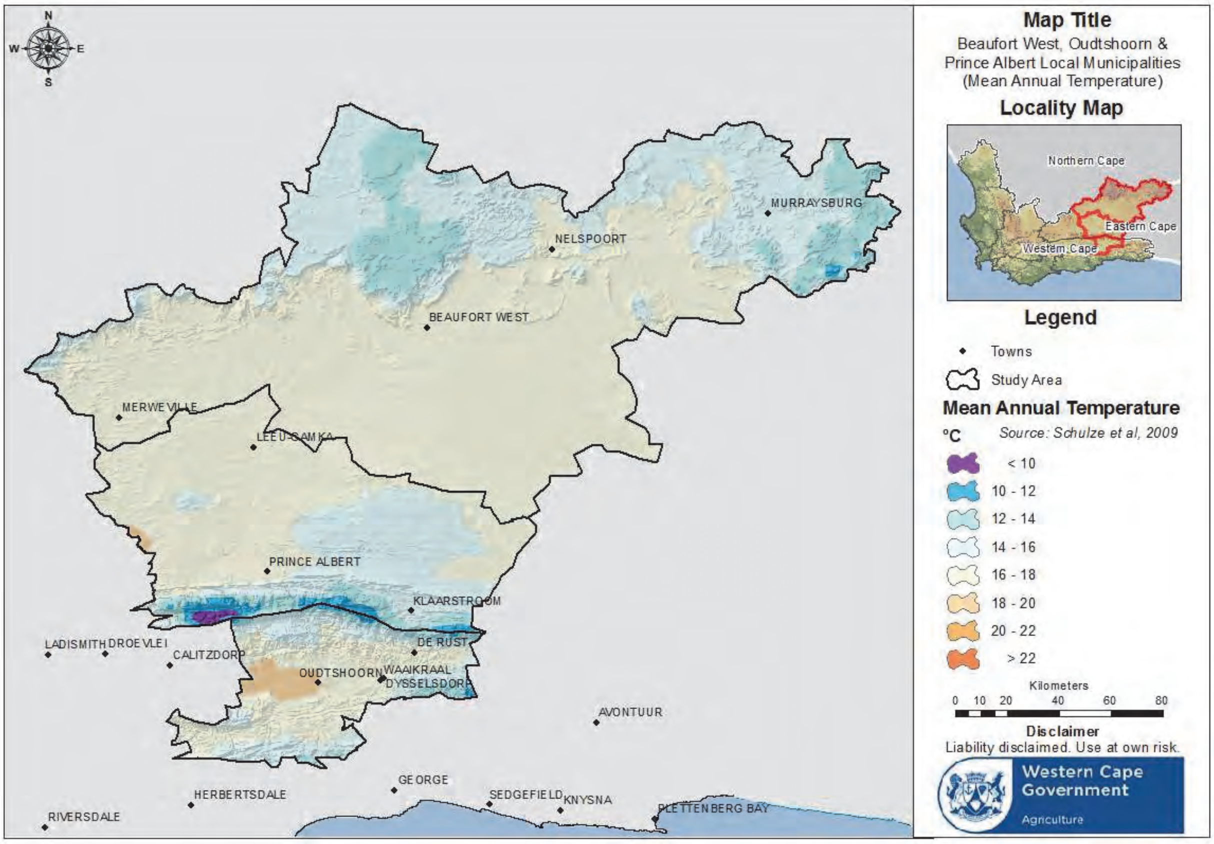

Figure 3.3 Mean Annual Temperature of Oudtshoorn, Prince Albert, Beaufort West (Source: Western Cape Government. Agriculture GIS Unit)

Prince Albert experiences high temperatures in summer and comfortable sunny but crisp conditions during winter with cold nights, reaching midwinter minimums of 2°C, with frost in places. Dry heat may spike up to 40°C on a few days in the summer with an average of 33-35°C. Winter days are sunny and warm (up to 25°C) with chilly nights (0°C). Beaufort West experiences mean annual temperatures of 18-20°C but like Prince Albert dry heat temperatures can reach up to 40°C. The monthly distribution of average daily maximum temperatures ranges between 16.8°C in June to 30.9°C in January. The region is the coldest during July when temperatures drop to 2.3°C on average during the night.

Temperature variation is usually used as predictor of weather conditions in scientific research. Farmers also have their ways of predicting weather, and for this project it was essential to find out if farmers also draw conclusions from temperature variations, and if so how close were their predictions compared to scientific methods.

3.3.4 Mean Annual Rainfall

Figure 3.4 shows mean annual rainfall for the three municipalities. Rain occurs throughout the year in Oudtshoorn, peaking in early winter and spring, and with thundershowers in the summer months.

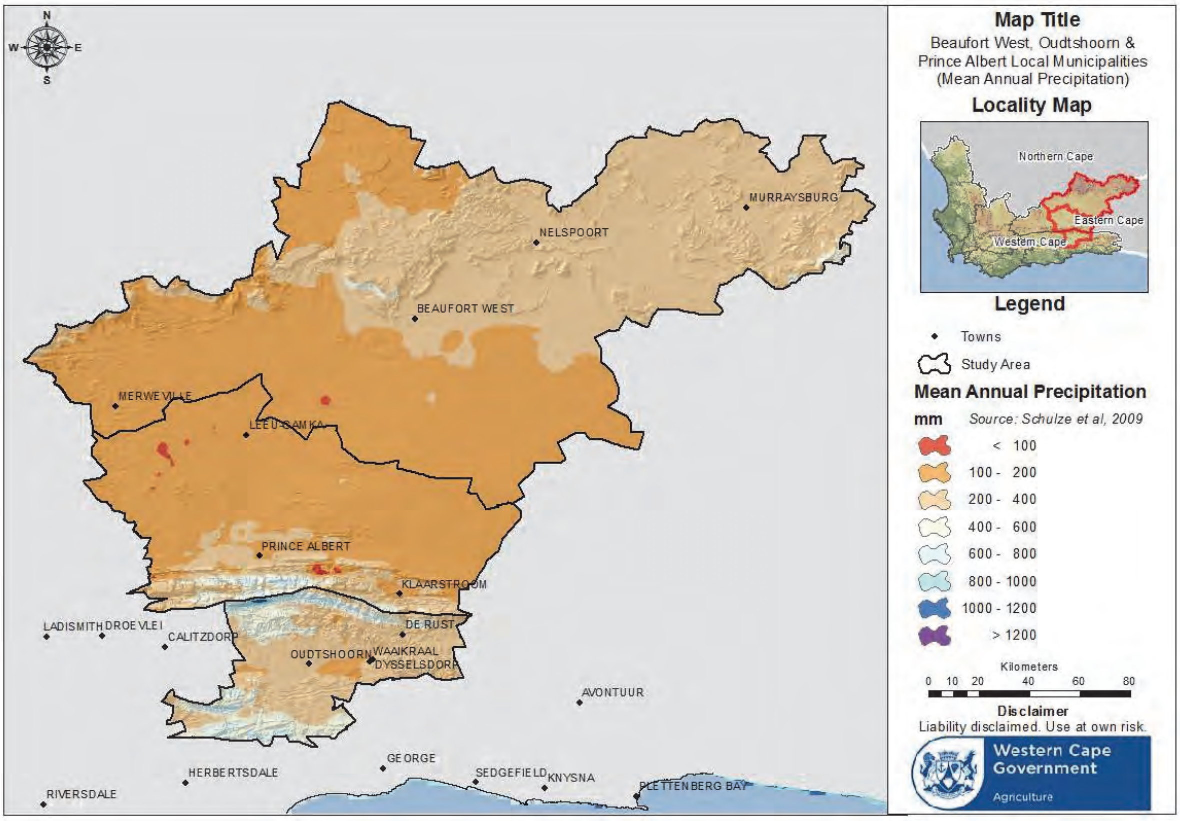

Figure 3.4 Mean Annual Rainfall of Oudtshoorn, Prince Albert, Beaufort West (Source: Western Cape Government Agriculture GIS Unit)

Rainfall is low in Prince Albert. Beaufort West receives about 160 mm of rainfall per annum, with most rainfall occurring during autumn. The lowest rainfall occurs in July (5 mm) and the highest rainfall occurs in March (33 mm).

CHAPTER 4: RESEARCH METHODS AND DATA COLLECTION

4.1 INTRODUCTION

The selection of farmers for the study was undertaken in collaboration with extension officers who have worked with the farmers for a long time. Participatory research methods were adopted for the whole study, particularly in interactions with the famers. The selection of participatory research methods usually depends not only on what you want to measure, but also the focus, purpose and timing of (Blackstock et al., 2007). Cornwall et al. (1993) identified institutional concerns such as time, financial constraints and conditionality of donors as some of the critical factors in addition to scientific relevance. All four concerns were important for the research. Grenier (1998) outlines that the indigenous knowledge (IK) research approach has borrowed from a number of sources and disciplines including International Union for the Conservation of Nature (IUCN), social science, gender sensitive research and participatory rural appraisal (PRA). A research framework for IK research should have the following considerations:

- Multiple, culturally appropriate methods that encourage broad participation (on the part of the participant and the researcher)
- Researchers bringing an appropriate attitude and an awareness of their own scientific bias
- The 3 Rs (respect, reciprocity, relationship) are maintained.

The project originally selected the following as appropriate methodology for capturing local indigenous knowledge in the project:

- Semi-structured interviews with individuals
- Focus group discussions that will incorporate tools such as historical matrix and ranking, participatory mapping, and transect walks, Venn diagrams, problem trees risk management and capacities matrix
- Field observations and participant observations where the opportunity arises.

4.1.1 Research Framework

Table 4.1 shows the research framework for the whole project.

Table 4.1 Research framework for WRC Project 2084

Phase	Aim	Main Questions	Methodology
1	Review international and local literature on capturing local indigenous knowledge around the experiences of drought in agriculture	What types of local indigenous adaptation strategies and actions can be identified? What methods are used for capturing local/indigenous knowledge? What framework is most widely used for assessing livelihoods strategies?	Review of existing local and international literature: Case study areas in arid and semi-arid regions of Africa, Latin America, Middle East, Asia and Australasia
2	Identify and develop an approach for identifying worst hit areas to select for study area	Which areas were worst impacted by the drought 2009-11? Which variables should be considered?	Provincial Drought Debriefing South African Weather Services (SAWS) Previous Studies

Phase	Aim	Main Questions	Methodology
3/4	Identify the type of agriculture the local indigenous population engages in	What are the types of local agricultural practices?	Secondary sources Primary sources (interviews and site visits)
5/6	Identify and capture any Coping and adaptation strategies adopted by communities in the Karoo	What historical and innovative local/indigenous practices can be identified? In which areas do the identified IK systems exist?	Participatory Approaches • Interviews • Focus group discussions • Field observations
7	Identify measures that would ensure the resiliency of the agricultural sector to future droughts	What are the "best" local indigenous coping strategies that should be upscaled? How can these best practices be balanced with appropriate technologies? What internal and external agency support is necessary?	Analysis of Fieldwork Integration of local/indigenous practices with scientific knowledge

4.2 CONSULATATION WITH WESTERN CAPE MINISTRY OF AGRICULTURE

4.2.1 Scoping Meetings

Scoping visits were carried out with the Department of Agriculture in Elsenburg followed by a field visit to Laingsburg, and a further meeting was held with District Extension Managers.

The first meeting was held in Laingsburg with one of the long serving Extension Officers in the Department of Agriculture. The main objectives of the meeting were to verify background information and data already collected on the research project including indigenous knowledge pockets. Guiding questions were used although the meeting was more of an interactive focus group discussion. The officer gave a broad overview of the farmer types found in Oudtshoorn, Prince Albert and Beaufort West. He also gave a general description of the farmer types in the whole research area.

A meeting was also held with the Director of Farmer Support and Development in the Western Cape, Department of Agriculture Office. The meeting was also attended by the Head of Extension Training. The objectives of the meeting were to obtain a detailed overview of the farming system and farmer types in the research site plus any indigenous knowledge systems. The team was advised that Elsenburg was the Head Office for the Department of Agriculture and they could provide a general overview of farming in the whole Western Cape Province. Detailed data and information was available through extension officers in the specific research areas. The Director therefore provided contact details of all the relevant offices and also committed to set up a meeting with the extension managers of the Little Karoo and Central Karoo regions.

The third scoping meeting was a focus group discussion with the Managers of the Little Karoo and Central Karoo Regions. The Managers also gave broad overviews of farming and indigenous knowledge systems in the areas that they cover, the Little Karoo region covering Eden District and Oudtshoorn, and the Central Karoo region covering Prince Albert and Beaufort West. The Managers then agreed to set up field meetings with extension officers within their areas.

4.2.2 Meetings with Extension Officers

Focus group meetings/discussions were carried out with extension officers in Oudtshoorn and Beaufort West in August 2013.. Data collection methods included focus group discussions, semi structured interviews, observation visits to the research farm in Oudtshoorn and observation visits to sites with potential indigenous knowledge systems in place. Questions asked during the visits covered the following:

- Description of different land use patterns
- Description of farmer types and farming types and mapping the identified farming types/methods
- Scientific knowledge/methods of drought management around
  - Scale of production
  - Scheduling/timing of activities
  - Resource management/optimization
  - Irrigation practices
  - Water resources management and conservation
- Mining indigenous knowledge around
  - Crop farming under the following sub contents
  - Livestock farming
  - Water resources management.

4.3 FARMER PARTICIPATORY RESEARCH

4.3.1 Sites for Indigenous Knowledge Mining

The selection of farmers for the study was done in collaboration with extension officers who have worked with the farmers for a long time. The selection criteria were based on the three Department of Agriculture farmer typologies of subsistence, smallholder (including emerging farmers) and commercial farmers. Crop, livestock and mixed farming systems were selected in order to cover all aspects of the Karoo agricultural systems. The sampling criteria also deliberately targeted long established farms that were likely to know more about indigenous knowledge systems through generational knowledge. Figure 4.1 shows the location of sites visited for indigenous knowledge mining.

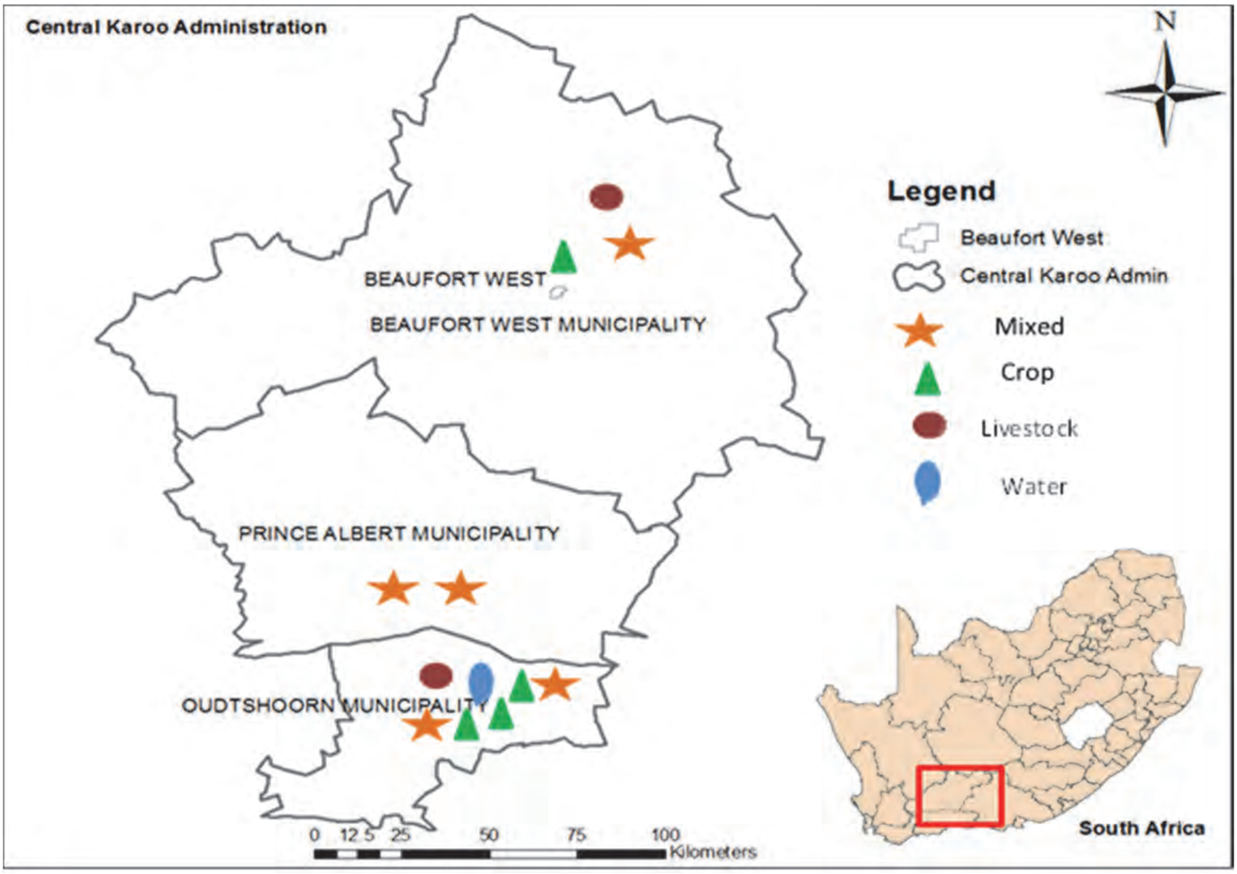

Figure 4.1 Location of sites visited for indigenous knowledge research

A total of 101 farmers were consulted during the research period and 7 extension and Landcare officers were interviewed during the project period.

4.3.2 Indigenous Knowledge Typology for Data Collection

There was need to develop a simple method for capturing indigenous knowledge. The project had to further categorize the farmers according to types and scale of production. The research additionally explored the indigenous knowledge signs and assessed if there were any differences in the way farmers recognised drought. Indigenous knowledge practices were explored in terms of practice and scheduling of farming activities. The product and commodity choices made by the different types of farmers were another way of assessing indigenous knowledge. The project also analysed resource management and optimization strategies adopted by the farmers. Finally the research assessed if there were any specific water conservation strategies implemented by the different types and groups of farmers. Table 4.2 shows the broad classes of farmers and the guiding questions developed under each category and management strategy.

Table 4.2 Farmer classes and guiding questions for each management strategy

	Subsistence Farming	Smallholder Farming	Commercial Farming
Generational Questions	• When did you start this project? • What are the objectives? • Describe the project. • Where do you get materials? Stones? Tanks? Seed?	• When did you start farming? • How long have you lived in this area? • Describe the farm and the farming methods. • Which methods did you inherit from your father? • Are the methods still significant?	• How old is the farm? Generations? • When did farming start? • What methods do you use? Describe the farming enterprise? • What methods has the farm used over the years? • Which methods have lasted for generations? Why? • Are the methods still significant?
Prediction	• How do you predict drought? Signs?	• How do you predict drought? Signs?	• How do you predict drought? Signs?
Changing Practices	• What changes do you make during drought? • What types of vegetables do you grow? • What fertilizer do you use?	• What are your objectives? Food, income, profit? • What activities do you carry out during normal seasons? • What challenges do you face during drought years? • How do you change practice when there is drought? • What are the alternatives for income generation when drought is severe?	• What are the main farming activities in your enterprise in a normal season? Crop/livestock? • What challenges do you face during drought years? • How do you change practice when there is drought? • What are the alternatives for income generation when drought is severe?
Reduction in Scale	• How do you cope with drought? • Do you reduce or abandon the project during drought?	• Do you decrease production during drought? How?	• Do you decrease production during drought? • What activities do you scale down and how do you compensate for the losses?
Scheduling	• Describe the process of scheduling system of tanks. • How efficient is the method?	• How do you schedule activities to cope with drought? • How do you manage planting dates? Do you practice late or early planting? • How do you manage other activities like weeding, fertilizer application etc? • Do you sell your livestock during drought? When? • How do you manage grazing? • How do you manage feed?	• How do you schedule activities to cope with drought? • How do you manage planting dates? Do you practice late or early planting? • How do you manage other activities like weeding, fertilizer application etc? • Do you sell you livestock during drought? When? • How do you manage grazing? • How do you manage fodder?
Water Management	• Is the water from rain water harvesting (RWH) enough for the whole year? • What other sources of water do you use?	• What are your sources of water? • How do you manage water during drought? • Do you practice RWH? How? • What other alternative sources of water do you have?	• What are the sources of water for your enterprise? • Do you have water rights? • How do you manage water during drought? • Do you practice RWH? How? • What methods of irrigation do you use? How do you manage irrigation during drought? • What challenges do you face in trying to increase water availability?
Soil and Water Conservation	• Describe the method of Mulching with pebbles? How effective is the method? • What else do you use to maintain soil fertility? • How do you reduce soil loss?	• How do you manage soil fertility? • What methods do you use to protect the soil?	• How do you manage soil fertility? • What methods do you use to conserve water and soil in the fields? • How do you conserve soil and water in the veld?
Other Resource Management	• What other coping strategies do use to cope with drought?	• What other activities do you carry out in order to cope with drought?	• What other activities do you carry out in order to cope with drought? • Do you have problems with invasive plants?

4.3.3 Field Consultation with Farmers

Three methods were selected for this part of the research; semi-structured interviews, focus group discussions and field observations. A number of recent studies have successfully used a combination of these methods to collect indigenous knowledge data. Orlove et al. (2010) used semi-structured interviews and focus group interviews to collect indigenous climate knowledge in Southern Uganda. A study of local farmers' perceptions of climate change and local adaptive strategies was carried out using key informant interviews via investigative questionnaires and informal discussions in Tibet, China (Li et al., 2013). Irangani and Shiratake (2013) used interviews with farmers, key informants, focus group discussions and field observations to collect indigenous knowledge used in rice cultivation. In Southern Malawi, Nkomwa et al. (2013) used qualitative data from focus group and key informant interviews and quantitative data from household interviews to assess the role of indigenous knowledge systems in adaptation to climate change and variability in the agricultural sector. The same methods used by these authors were used in the Karoo with slight variations to suit the farmer conditions.

Focus group discussions

Focus group discussions provide people with a structured opportunity to speak freely on issues pertinent to the research questions (Mosavel et al., 2005). There were 11 farmers in one group of smallholder farmers, the Zoar community, an indigenous Khoisan Community. We decided to use the focus group approach with this group because it would not have been possible to interview them one by one, given the time and resource limitations. The group has a long history of working together; therefore they were very comfortable discussing issues that are common to them as a group. This technique can help identify collective problems and solutions (Grenier, 1998). We met the farmers at one of the member's house.

Key informant interviews

Semi structured interviews were the main tool used to collect qualitative data. A semi-structured interviewing and listening technique uses some predetermined questions and topics but allows new topics to be pursued as the interview develops. The interviews are informal and conversational, but carefully controlled as recommended by Grenier (1998).

A set of questions was developed for each of the three farmer groups, subsistence farmers, smallholder farmers and commercial farmers, based on the initial findings and discussions with extension officers. Grenier (1998) agrees that in some cases the structured questionnaire with its direct question and answer format may be effective for interviewing although in other instances; a more casual conversational approach may be most suitable. We used a variation of both formal and informal interviews depending on the setting of the interviews and the comfort initially exhibited by the farmer in the interviewing process. The extension officers acted as the local researchers in the interviews. The extension officers did the initial introduction and purpose of the visit, followed by a detailed introduction and description of the project by the project researcher including the possible implementation of the outcomes. Once this was done the farmers seemed to relax and they were happy to answer the questions. The interviews took at least an hour as the researchers were conscious of the busy work schedules of the farmers.

Field observations

The interviews were immediately followed by transect walks and guided field walks through the farm to observe, listen to and identify areas of interest and further clarification. In some cases the farmers demonstrated the use of certain farm implements and how they carried out certain activities. Participant observation is described as the ideal method for documenting and understanding traditional knowledge where a local researcher and a scientist work together as a team to interview the informants in as natural a setting as possible as was done in this project. With this method outsiders can quickly learn about topography, soils, land use, forests, watersheds and community assets (Grenier, 1998).

4.4 VALIDATION WORKSHOPS AND MEETINGS

The last part of the project involved verification of the results with specialists in drought management as well as the extension officers.

A meeting of the technical group of reference group members of the project met to discuss the final results of the project. The group reviewed the coping and adaptation strategies identified in the project and agreed that the results were valid. The group also attempted to develop an overall classification system of Karoo farmers. The classification was based on land ownership and farming activities.

Project results were also presented to Extension and Landcare officers covering all areas of the project site. The workshop was also attended by two participants from the Disaster Risk Management office from the Western Cape. A presentation was done followed by a plenary discussion of the results. The group was also asked two questions which they answered in group discussions. The questions were:

- What should drought preparedness include in the Karoo region?
- Which strategies should research focus on, in order to improve the livelihoods of emerging farmers? Why?

The last meeting was held with the Chief Director of the Western Cape Department of Agriculture and the two District Managers who were consulted before field data collection. The project results were presented to the panel followed by a plenary discussion.

CHAPTER 5: COPING WITH AND ADAPTATING TO DROUGHT IN THE KAROO

5.1 TYPOLOGY AND GENERAL CHARACTERISTICS OF FARMERS

5.1.1 Classification of Farmers

The objectives of this project were to capture insights of IK in agriculture in the Karoo. In order to do this, a South African farmer typology needed to be well understood. The research team and some of the technical advisors to the project attempted to develop a classification system based on their experiences in the field and current literature. Figure 5.1 shows the classification based on the two main sectors and indicating how the sectors further divide into farmer types and farming systems generated after a technical workshop of reference group members and the research.

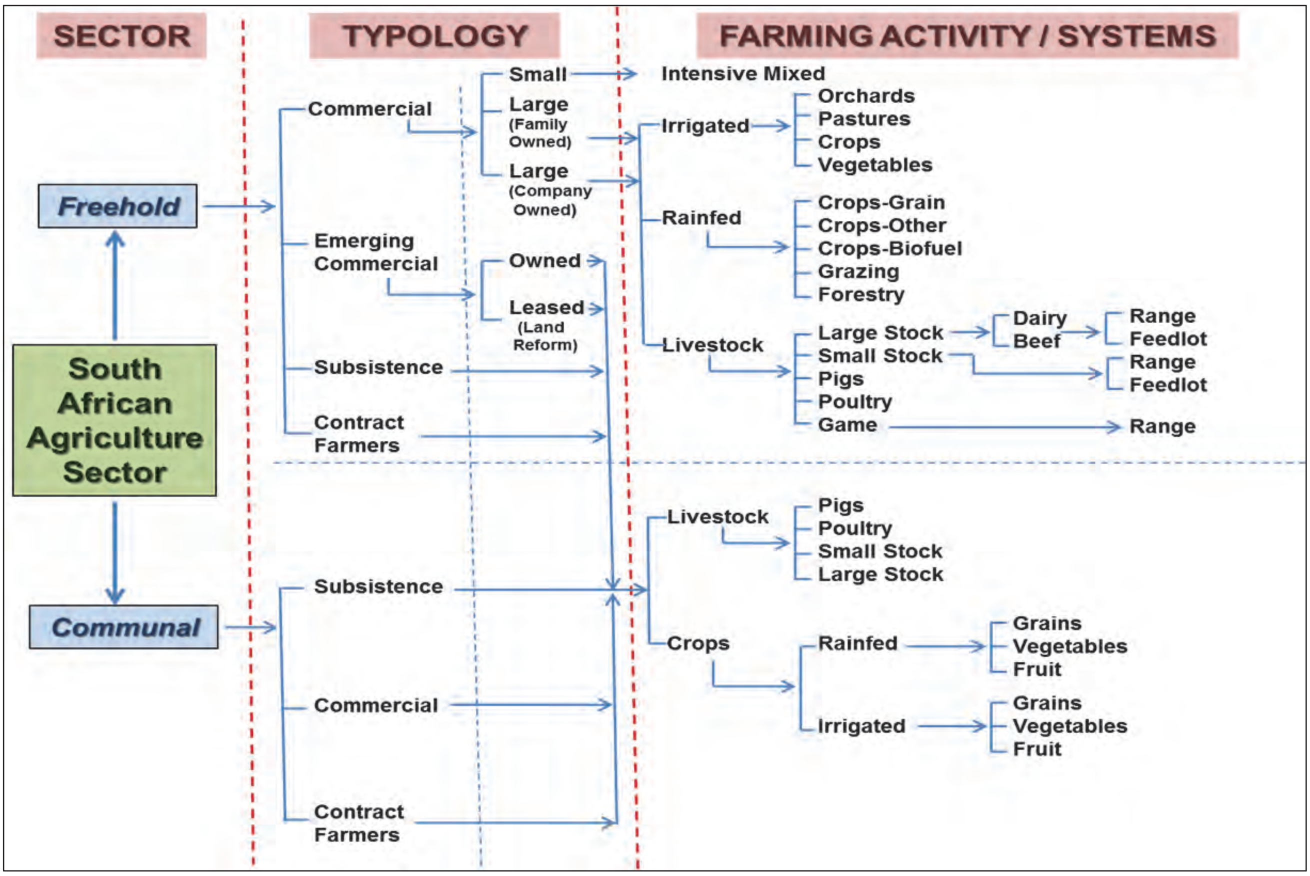

Figure 5.1 Classification of the South African farming sector

The system prior to 1994 was commercial and subsistence, but recently three accepted farmer classes were characterised and defined. These are subsistence, smallholder and commercial farmers (DAFF, 2013).

5.1.2 Subsistence Farmers

The South African Department of Agriculture defines subsistence farmers as *resource poor farmers producing mainly for household consumption and according to their family food requirements rather than* *markets* (DAFF, 2013). In the project site subsistence farmers were cultivating small patches of land behind buildings. The activities fit with other definitions of subsistence farming where activities are conducted mainly for personal consumption, characterised by low productivity, risk and uncertainty (Kostov and Lingard 2002), and household members almost exclusively provide farm labour (Daskalopouluo and Petrou, 2002). The project implementers were, however, not purely subsistence farmers, but teachers and community members who had set up projects to serve the children and the community. The oldest project had been operating for 20 years and was set up by a nurse to provide supplementary nutrition for mothers of premature babies. Over the years the project had grown into a crèche and the vegetables are now used to feed crèche children and vulnerable members of the community. In all projects the government is involved through the provision of tanks for rainwater harvesting or giving horticultural advice through agricultural extension officers.

5.1.3 Smallholder farmers

Robert (1993) defines smallholder farmers as rural cultivators practising intensive, permanent, diversified agriculture on relatively small farms in areas of dense population. The Department of Agriculture (2013) defines smallholder farmers as farmers *who produce for household consumption and markets subsequently earning ongoing revenue from their farming businesses, which form a source of income for the family. Farming is not always the main source of income; diverse non-farm sources of income exist to sustain the family. They have the potential to expand their farming operations and to become commercial farmers, but need access to comprehensive support (technical, financial and managerial instruments)*. There were 3 types of smallholder farmers in the Karoo. Typical smallholders who own about 2 ha of land, and use leased land in order to increase farmed area. Access to water enabled these farmers to farm intensively and maximize resource use on the small pieces of land. Figure 5.2 shows resource flows in a typical smallholder farm with access to enough water in Matjiesrivier in Oudtshoorn Municipality.

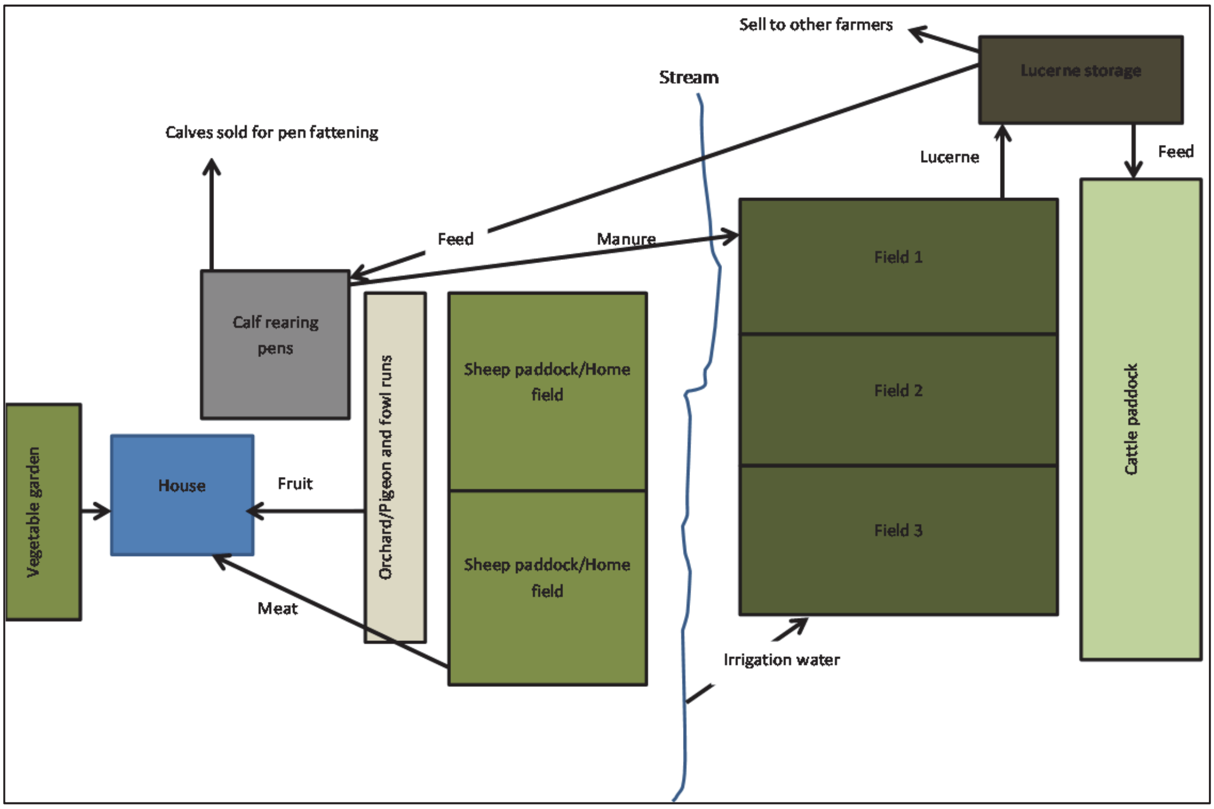

Figure 5.2 Resource map of a typical smallholder farm in Matjiesrivier, Karoo

The farmer runs an almost closed system. His main business is the calf rearing project, whereby he buys newly born calves, feeds them until they reach 80 kg then sells them to pen fattening farmers. The farmer also grows lucerne which he rotates with cereals or grass every 5 years. The lucerne is grown mainly for sale to other farmers, but the farmer keeps the first cut to himself to feed the calves. He also has 6 cows and a small flock of sheep which he keeps for his own consumption. He provides most of the labour himself but hires 3 casual labourers during busy times.

There was another group of smallholder small stock farmers, the Zoar Community who carry out their activities as a group. The group is the 5th generation of the original Khoisan community who settled in Zoar in the early 1870s. Each farmer has a known number of animals, but daily management of the flock is done collectively by 3 permanently employed herdsmen.

Emerging farmers were also part of the smallholder farmers. The term ‘emerging’ farmer was used with different connotations depending on the institution being consulted. The farmers however said they see themselves as farmers in transition towards commercial farming. A group of 8 beneficiaries who started farming in 2010 were part of the study. They farmed on 3700 ha of land rearing 200 Angora goats for mohair, and 300 sheep for mutton. The farmers have received technical assistance from the government and through training by collaborators such as Stellenbosch University. It was however ironic that the same group of farmers had no access to water for irrigating lucerne to feed the sheep. They were going through a complicated system trying to retrieve original water rights for the farm.

5.1.4 Commercial farmers

The Department of Agriculture (2013) defines *commercial farming as the established farming venture undertaken by an individual or business entity for the purpose of the production and sale of agricultural products to make a profit*. Most commercial farms in the Karoo have been in existence since the 1800s. The farmers that were interviewed ranged from 3rd to 5th generation. Farm sizes ranged from 1800 ha for intensive crop farms to 20 000 ha for extensive livestock farms.

Crop farms were producing fruit (olives, apricots, prunes) and some also had smaller components of livestock farming of sheep and/or goats, and ostriches in some cases. Livestock farms were mostly small stock farmers rearing sheep and goats. They also had a small component of lucerne production for pen feeding during winter and drought periods. The main objective of commercial farming is to make profit although economies of scale, specialization, capital intensive farming techniques, labour saving technologies and maximizing of yield are also practised (Robert 2013). Most of the commercial farms in the Karoo were successful businesses producing fruit for export and meat for the local market. Ostrich farming used to be a major activity in the area, but due to the avian influenza production is currently very low. Under normal circumstances the ostrich industry in Oudtshoorn produces 80% of the breeding herd, and the area has the best gene pool in South Africa. To preserve the gene pool some ostriches have been moved to Stellenbosch and the West Coast, although some farmers still keep reasonable flocks in their farms.

5.2 FARMING SYSTEM TYPOLOGY FOR COPING AND ADAPATION TO DROUGHT

A number of studies have developed typology for different situations and systems in South African agriculture. Verschoor et al. (2006) developed farmer typologies for agricultural development criteria for project design and implementation. There are a number of case studies describing farmer typologies for different scenarios (Zingore et al., 2005, Ncube et al., 2009, Barnes et al., 2011). The common factor in these studies is that their main objectives were to develop typologies and farmer classes for certain objectives and criteria. The accepted classification of smallholder, subsistence and commercial did not fit well with the farmer classes in the Karoo. IK could not be presented using coping strategies only which are short term; there was need to also present adaptation strategies that farmers have developed over a long period.

A simpler and clearer classification was needed in order to capture IK for most of the systems in the Karoo. Classification using production systems was adopted in order to capture indigenous knowledge by production systems. Table 5.4 shows the three broad production systems used for the classification of farms in the project.

Table 5.1 Classification of identified production systems in the Karoo

Main System	Types of Production Systems
Crop Production Systems	• Subsistence horticultural systems
Mixed Crop-Livestock Systems	• Smallholder Pasture-Livestock Systems • Commercial Fruit Orchard-Livestock Mixed Systems
Livestock Production Systems	• Commercial Small Stock Production Systems

Crop production is not a major activity in the dry Karoo region. Most crop production takes place in the wetter Oudtshoorn Municipality. Farmers are not purely involved in crop production except subsistence farmers who grow vegetables. There were various levels of mixed crop-livestock systems of olive and apricot orchards with lucerne grown to feed herds of livestock that usually form a minor component of the farming systems.

5.3 DEFINING DROUGHT IN THE KAROO

5.3.1 Defining Drought

"The Karoo is a desert". "To farm in the Karoo you have to believe in God". "90 % of our problems are solved by water". This was the general view of how difficult it is to farm in the Karoo. However, "We know our type of weather", indicates that the farmers have learnt to survive in the dry conditions in their environment. O'Farrell et al. (2009) describe the approach as enduring drought, 'sitting it out' without damaging biological resources in the long term. The authors explain in their review that drought remains a stressful and often crippling event for farmers across all sectors in South Africa today. The authors give four definitions of drought:

- **Meteorological drought** – a reduction in rainfall supply compared with a specified average condition, less than a certain amount (e.g. 70%).
- **Agricultural drought** – a reduction in soil water availability below the optimal level required by a crop during each different growth stage, resulting in impaired growth and reduced yields.
- **Hydrological drought** – the impact of a reduction in precipitation on natural and artificial surface and subsurface water resources.
- **Socio economic drought** – the impact of drought on human activities, including both direct and indirect impacts.

O' Farrell et al. (2009) further described drought as a climatic event with relatively predictable biophysical repercussions, social perceptions and responses to drought, at individual through community to state level.

Farmers described drought in terms of the way it affected the agricultural systems; low rainfall, decrease in water availability, reduced grazing quality and quantity, dying vegetation and animals, food and feed shortages. The descriptions covered all the drought definitions given by O'Farrell et al. (2009). The descriptions were also very similar to the descriptions given by extension officers in previous research visits.

5.3.2 Drought Occurrence in the Karoo

Drought is not a one season occurrence in the Karoo. The oldest extension officer described drought as a long term process that is accompanied by changes in the environment that may not be obvious to someone who has not lived in the Karoo for a long time. Farmers concurred with the extension officer. The farmers described drought as occurring over a period of up to 3 years, and only people who live and farm in the Karoo can understand that. The Zoar community described the occurrence of a 7 year drought in their area, from 1978-1985. All farmers were also aware of a seasonal dry period which occurs between October and December every year and they viewed this period as normal.

Farmers in the Karoo region remembered the 1960s drought vividly. There was no rain in the period 1960-1963. The period 1966-1969 was also a major drought period. None of the interviewed farmers thought 2009-11 was a drought because their farming systems were not seriously affected. The Zoar community remembered the 1978-1985 drought period vividly. One farmer in Beaufort West said the period 1983-1992 was a major drought in his area, and another farmer said he had lost a sizeable number of his herd in 2004 due to drought. A smallholder farmer living near the Swartberg Mountains said he was farming in the blessed valley because there was always enough water except during the exceptional 1960s drought. This probably indicates a large variation in the occurrence of drought within the region or it could also be an indication that farmers remember the devastation of a drought by the amount of loss they suffered.

Farmers were also asked to describe indicators of drought in the Karoo. Instead farmers gave indicators of both drought and weather phenomenon indicating good seasons. The behaviour of plants and animals was also described by farmers. Table 5.2 shows animal and environmental indicators described by Karoo farmers.

Table 5.2 Animal behaviour and environmental indicators of weather

Weather indicators related to animal behaviour	Environment related weather indicators
• Presence of angulate tortoise (*Chersina angulate*) indicates thunderstorms • Terrapin tortoise (*Pelomedusa subrufa*) moving down the mountain indicates drought, and when it goes up it indicates rains • Snakes coming down the mountains indicates drought • Blue crane circling up high in the sky indicates the thunderstorms • A Bustard bird (*Eupodotis vigorsii*) in the veld is an indication of rain coming in few days • Presence of small insects (the ashcar) indicates rain in 14 days • Game not breeding/lambing indicates drought • Calves running and playing in the fields indicates rain in few days • Black ants (*Lasius niger*) collecting food to store indicates rain in a few days • Animals die due to water and food shortages (including donkeys)	• Very high day and night temperatures indicate drought • Very dry winter, and strong dusty winds indicate drought • Westerly winds indicate there will be drought • South westerly winds indicate there will be rain during the rainy season • Easterly winds indicate rain will be coming • Very dry conditions, no grass in the veld indicate drought • Water sources drying indicate drought conditions • Drying of fountains and low water tables in the boreholes indicate drought conditions • When the rain flower produces flowers the following day it will start to rain soon • Shortages of food for the animals and humans indicates drought. • Appearance of certain plant species predicts drought

Weather predictions mentioned by the Karoo farmers were similar to weather predictions that have been reported in other parts of the world. In a study carried out in Malawi by Kalanda-Joshua et al. (2013), farmers indicated that seeing a certain local bird near households indicated rain in less than a week and the croaking sound of frogs was an indicator of imminent rains. In other studies carried out by Nkomwa et al. (2013), farmers in southern Malawi mentioned high temperatures, delayed unpredictable onset of rains, declining rainfall, and increased frequency of prolonged dry spells as indicators of pending drought. The shedding of leaves and the later production of flowers by tree species than their usual time indicated drought. Examples of the trees included baobab (*Adonsonia digitata*), *Cordyla Africana, Faidherbia albida* and *Mangifera indica* (mango).

In Tibet farmers determined sowing time by observing the actions of migratory birds such as swallows (*Cuculus poliocephalus*), woodpeckers (*Cuculus canorus*), swans and red billed crows. An unusual temperature increase was viewed as an indicator of drought (Lil et al. 2013). Orlove et al. (2013), reported that farmers in Southern Uganda used the increase in night time temperatures, the timing of flowering of trees, the call of hornbill birds, shifts in the direction of prevailing winds, the appearance of whirlwinds and change in the direction prevailing of winds as some of the indicators that the rains would start in a few weeks.

There are other examples of climate and weather change related studies done in Zimbabwe and Zambia where farmers gave perceptions regarding drought, floods, extreme temperatures, dry spells, and late/early rains (Mubaya et al. 2012). In the Free State, South Africa, farmers in Gladstone also gave perceptions on rainfall and temperature and their impacts on the agricultural systems and how they adapted (Gandure et al. 2013).

5.4 COPING AND ADAPTATION STRATEGIES TO DROUGHT IN HORTICULTURE

5.4.1 Reducing Drought Impacts on Vegetable Production

Subsistence farmers in the Karoo live in water stressed environments. Water sources included expensive municipal systems or roof rainwater harvesting and storage in tanks. Subsistence farmers visited under the project were all involved in vegetable production for supplementing nutrition in the community. The projects were set up by individuals who saw a need to support local communities. Drought impacts included extreme shortages of water to irrigate vegetables. As a result productivity was very low due to reduced yields. Table 5.3 shows coping and adaptation strategies adopted by subsistence vegetable famers during drought in the Karoo.

Table 5.3 Coping and adaptation trategies dopted in crop production systems

Drought Impacts	Coping Strategies	Adaptation Strategies	Modern Scientific Methods
Water shortage	• Sustainable water management through recycling kitchen water • Perforated bottle/can dug into the soil to provide soil moisture at root zone • Shade netting to reduce evaporation • Grass and saw dust mulching to conserve moisture	• Digging boreholes for reliable irrigation water supply • Rainwater harvesting	• Roof rainwater harvesting and storing water in tanks • Drip irrigation
Loss of vegetable yields	• Creating own seed banks by retaining seed • Planting different varieties if vegetable	• Change in planting and harvesting times • Using short season varieties • Introducing new seed varieties	• Introducing new cultivars/varieties • Change in planting and harvesting times
Loss of crops due to poor soil water conservation	• Picking and applying cow dung into the soil • Applying kitchen garbage into the soil to conserve moisture and soil fertility	• Soil fertility and structure maintenance using manure and compost • Mulching to conserve moisture • Construction of permanent compost heaps to make compost	• Use of chemical fertilizer

5.4.2 Water Conservation Strategies

Subsistence farmers opted for water conserving methods during drought years. Water from the kitchen was used to water vegetables by Poplap Creche, and this has been practiced for a very long time. The farmers have developed in innovative ways of conserving water in the vegetable beds. Small holes are perforated on the sides of a 2 litre plastic bottle, which is then dug into the ground in the centre of the vegetable bed. The bottle is then filled with water and the water is allowed to seep into the soil slowly to keep it moist over a number of days (Figure 5.3).

Figure 5.3 Perforated water bottle to supply moisture to vegetables

Normal watering with a bucket was done once a week to cover the whole vegetable bed. Another version of the innovation was to use small perforated cans dug into the soil in the corners of the vegetable beds. The farmers said these methods worked very well and they could keep the vegetables moist for longer periods, and save water. Farmers also reduced moisture loss through the use of grass and saw dust mulches. A recently adopted method includes the use of shade netting to reduce evaporation from the vegetable beds. Figure 5.4 shows show shaded vegetable garden at H.M. Dlikidla Primary School in Beaufort West.

Figure 5.4 Shade Netting of Vegetables at H.M. Dlikidla Primary School, Beaufort West

Long term adaptation strategies included digging boreholes to ensure a more reliable source of water. Rainwater harvesting from roof tops is another long term strategy that subsistence farmers have adopted to ensure annual water supply. Water is stored in the tanks and it is only used during severe drought periods.

5.4.3 Vegetable Yield Improvement

Subsistence farmers have created their own seed banks by retaining seed harvested from the vegetable patches to avoid annual seed purchases. Farmers also planted drought-resistant vegetables such as cabbage when it was too dry. Long term strategies include changing planting times, using short season varieties or introducing new vegetable varieties.

The Poplap Crèche faced poor soil fertility problems. The farmers use household rubbish and fruit peel to improve soil fertility. Cow dung is also picked near drinking water sources and it is crushed and applied into the soil. Long term strategies included manure and compost that were used to improve soil fertility. Subsistence farmers also conserved soil and water through building bunds and ridges around vegetable beds to prevent soil from washing away. Stone barriers were also built to prevent water from eroding the soil.

5.5 COPING AND ADAPTING TO DROUGHT IN MIXED CROP-LIVESTOCK SYSTEMS

Crop production is not a major activity in the dry Karoo region. Most crop production takes place in the wetter Oudtshoorn Municipality. Farmers are not purely involved in crop production except subsistence farmers who grow vegetables. There were various levels of commercial mixed crop-livestock systems of olive and apricot orchards with lucerne grown to feed herds of livestock that usually formed a minor component of the farming systems. Smallholder farmers also did not engage in crop farming as their sole farming activity. They were livestock farmers who engaged in crop farming when conditions were wetter. Cropping included planting lucerne to feed livestock during winter and planting vegetables for household consumption.

Table 5.4 Coping and adaptation strategies to drought in mixed crop-livestock systems

Drought Impacts	Coping Strategies	Adaptation Strategies	Modern Scientific Methods
Water shortage	Planting small areas Irrigating small areas Managing water through minimal irrigation to keep the orchards alive but not produce fruit	Rainwater harvesting from the mountains Water allocation – water rights review Rain water harvesting from the mountains Construction of stock dams to conserve water Drilling boreholes Planting cover crops to conserve soil water	Dam construction Roof rainwater harvesting Water allocation review Drilling boreholes Irrigation scheduling Using probes to monitor soil moisture
Shortage of livestock feed	Purchasing lucerne from other farmers for supplementary feeding Importing lucerne from other areas	Long term storage of lucerne Planting saltbush, Prosopis* and Agave as alternative feed species	Supplementary pen feeding Government voucher scheme to purchase feed during drought
Loss of animal condition	Destocking and leaving the breeding herd Early marketing of livestock	Changing the herd to drought-resistant livestock breeds Changing systems to low input ostrich or game farming	Supplementary pen feeding Government voucher scheme to purchase feed during drought
Loss of fruit yields	Growing short season cash crops such as tomatoes and green mealies to improve cash flow Maintaining small herds of livestock to keep the farms running	Setting up alternative low input system as focal enterprise Changing systems to livestock only Changing to alternative high value crops	Setting up high values enterprises that may include Lavender and Jojoba oil plants Drought cycle management systems
Soil fertility management	Using manure to improve soil fertility	Establishing crop rotations to maintain soil fertility	Applying chemical fertilizer to replenish soil fertility

*Prosopis is classified as alian vegetation in South Africa

5.5.1 Reducing Water Shortages

Farmers practising mixed farming responded to water shortage in crops by planting and irrigating small areas. Commercial farmers have established methods of scheduling their activities to cope with dry conditions. Less water is used for irrigating trees during drought just to keep the plants alive. Commercial farmers' water supply schedules were based on water rights cycles, some of which date back to 1817. Olive and apricot farms also used micro irrigation systems that are designed to irrigate when moisture is needed. This ensures efficient use and conservation of water. In addition the farmers planted mulching cover crops to keep the orchards cool and reduce evaporation. Long term adaptation strategies included building stock dams around the farms that collect water via sluits from rivers when it rains, and water is then distributed to the dams via pipes and canals. During drought years there is heavy reliance on boreholes to irrigate tomatoes and melons via drip systems. Some farmers also selected one focal enterprise and concentrated on one activity that would keep the farm running until conditions normalised.

Some smallholder farmers had access to water through the water rights systems, and this ensured reliable supply for irrigating lucerne and other crops. However, emerging farmers did not have the same level of access as the Zoar Community and other smallholder farmers, and as a result they could not irrigate lucerne.

5.5.2 Reducing Shortage of Livestock Feed

Farmers purchased lucerne from neighbouring farmers to feed livestock during drought periods. Some farmers even imported the fodder from other regions. Commercial farmers always store fodder and hay to feed animals or ostriches during the dry season. About 90% lucerne is produced to feed livestock and ostriches in normal seasons. When drought seasons approach farmers are able to store a lot of lucerne for even up to 5 years. When severe shortages occur farmers import fodder from other farmers. Some farmers also resort to salt bush (*Atriplex nummularia*) planted as a drought-resistant crop, which is high in protein. Prickle pear (*Opuntia*) is also used as fodder during drought years and in addition the sale of the fruit provides. Agave (*Agave americana*), is used to feed ostriches during drought periods although not much is produced.

Saltbush plant is also given to animals for fodder purposes, but it is taken as a supplement to feed animals in some areas with sour veld such as Oudtshoorn, but rarely in Beaufort West because the veld is naturally salty. The use of mesquites (*Prosopis*) an alien plant introduced from South America as a drought fodder is also done in Beaufort West during dry seasons. Prosopis is a drought-resistant plant that animals can graze, but it is no longer accessible. Due to cross breeding the plant has grown into thick impenetrable bush and it is now competing for water with local species.

5.5.3 Improving Animal Condition

During drought years farmers face many challenges as animals quickly lose condition when there is not enough food. Some farmers opt to early marketing of their livestock in order to avoid loss of profit. Another coping strategy is supplementary feeding of animals based on their condition. Supplementary feeding for ewes is done when they are ready for lambing. Most farmers plant lucerne and bale it for supplementary feeding during drought periods, while some farmers also buy lucerne from other farmers to pen feed the animals.

Long term adaption strategies include changing the herd to more drought-resistant species, hence improving survival during drought periods. Some farmers also change the systems altogether, to low input systems such as ostrich and game farming. Ostrich farming has always been an alternative low input system for farmers in the drought prone Karoo region. However, due to the recent outbreak of bird flu farmers are not actively involved in ostrich production anymore. Some farmers are however still rearing ostriches mainly for gene selection. The knowledge and infrastructure for ostrich production still exists in the region. It is likely that the gene pool that remains after the outbreak will be the core head that will be resistant to the virus, and farmers can restart ostrich production again. Game farming is not seen as a separate production system in the region. Game farming exists in some of the farms in Oudtshoorn as part of the main farming systems. Game farming is done mainly for tourism purposes, hence the Oudtshoorn area is known for tourism.

5.5.4 Reducing Fruit Yields Losses

Commercial farmers also faced challenges during drought which eventually forced them to change their farming practices. Some farmers diversified into small stock and ostrich production during drought years and maintained the fruit trees alive but not producing fruit. These activities do not require as much water as fully irrigated fruit orchards. Some farms diversified into vegetable seed production which also does not require a lot of water, e.g. onion seed. Some crop farmers selected one focal enterprise which did not require too much water such as vegetable seed production and they practiced that until the drought was over. One farmer said he produced tomatoes and green mealies grown in small areas to sell and generate income. Some farmers would even consider leaving the farm and doing something different from farming for income generation when there is severe drought.

Long term strategies included changing the whole farming system from mixed crop-livestock to livestock only. Some farmers set up alternative low input systems permanently. Changing to high value crops such as oil plants like Lavender and Jojoba was seen as a viable adaptation strategy where limited amounts of water were available.

5.5.5 Soil Fertility Management

Poor soil fertility is also a problem in some crop systems. Soil fertility improvement strategies include the use of manure, a practice that has been done for many years. Some farmers have also established long term crop rotations to maintain soil fertility, for example every 5 years lucerne fields are planted with cereals without a need to add any extra manure or fertiliser. Fertiliser application is seen as a scientific method, but the use of fertiliser dates back to so many years that it has become a local practice.

5.6 COPING AND ADAPTATION STRATEGIES TO DROUGHT IN LIVESTOCK SYSTEMS

5.6.1 Introduction

Most of the Karoo Region is involved in livestock production at different scales. Small stock production is a major activity, although some farms also have small herds of cattle. Some farmers also keep game such as springbok. Commercial farms were in the hands of 3rd to 5th generations, and most farms were inherited from the fathers. Most farmers were original descendants of farmers who settled in the early 1800s. Most farms were seen as businesses as well as means of survival. Some farmers had worked on the land all their life.

Smallholder livestock farmers have been on the land for generations except emerging farmers who settled in recent years. The Zoar Community Khoisan community settled in the area in the 1870s. The oldest members are the 3rd generation of the community. The community practices small livestock farming as a group of 7 farmers. They are involved in traditional goat farming and each member owns 10-80 animals. They share all resources including land, water sources and herdsman. Their main objective is to sell the livestock to get income for food and clothing. They also slaughter some animals for food.

Emerging smallholder farmers are farming along the same lines as the Zoar community (as a group), but the difference is that their land was purchased under the government land reform programme. There were 8 beneficiaries in Swartrivier, the farm that was visited. The farmers brought 300 goats from commonage land. They sold the animals and invested in developing infrastructure in the new farm. Later the farmers started an Angora goat farming project for Mohair, with the assistance of strategic partners. They also received financial management training and technical assistance. The model seems to be working well so far, although water shortage is a major problem.

Drought impacts in the livestock systems are similar to the impacts faced by mixed-crop livestock systems and coping and adaptation strategies are therefore quite similar. Table 5.5 shows drought impacts, coping and adaptation strategies in the livestock systems.

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Table 5.5 Coping and adaptation strategies to drought in livestock production systems

Drought Impacts	Coping Strategies	Adaptation Strategies	Scientific Coping and Adaptation Strategies
Land degradation/Shortage of grazing	• Grazing along the roadsides • Migration with animals to areas with more grass • Importing fodder from other regions •	• Creation of paddocks/camps to conserve grazing lands • Construction of spreader banks to conserve moisture in the grazing lands • Planting lucerne • Creating fodder banks • Planting saltbush, Prosopis and Agave as alternative feed species	• Supplementary pen feeding • Rotational grazing • Adopting the ecological principle to maintain grazing lands, and manage livestock units based on the carrying capacity of grazing lands
Low survival/productivity of livestock	• Early marketing of livestock • Destocking and leaving the breeding herd • Manipulating feeding strategies to conserve the herd	• Breeding for survival during drought • Changing breeds, e.g. from Boer goats to more drought-resistant Angora goats • Changing systems to low input ostrich or game farming	• Government voucher scheme to purchase feed during drought • Supplementary feeding
Increased loss of lambs due to predation Increased vulnerability to drought due to kraaling	• Weaning around homesteads	• Use of trained shepherd dogs to protect livestock in the veld.	• Reducing the population of predators.
Low survival of animals due to diseases	• Treating animals with natural plants	• Traditional animal disease management methods.	• Veterinary services and vaccination
Land degradation/Soil erosion	• Use of brushwood and stones to conserve soil	• Building weirs and sluits to provide long term erosion control	• Construction of gabions and storm drains • Construction of spreader banks
Water shortage due to siltation of dams	• Using donkey pulled scoopers to rehabilitate dams	• Building silt traps/sluits to prevent dam siltation • Construction of contours across slopes to conserve soil	• Building spreader channels in grazing lands to prevent soil erosion •
Water shortages	• Water management and water saving	• Rainwater harvesting from mountain slopes • Construction of stock dams for water storage • Windmill pumped boreholes	• Building modern electricity and solar powered boreholes • Roof rainwater harvesting and storage in tanks.
Invasive plant encroachment in grazing lands	• Cutting and burning alien vegetation	• Rehabilitation of cleared lands by planting trees	• Use of chemicals to destroy alien vegetation

5.6.2 Controlling Land Degradation and Reducing Shortage of Grazing

The grazing capacity of the veld should always be kept at the optimum in order to prevent the veld from degradation due to over grazing. Camp rotation is also done to prevent overgrazing. Maintaining the right stocking rate also prevents soil degradation in the veld.

Farmers are still using traditional indigenous methods to control soil erosion in the veld when it occurs. All farmers said they still use stones in furrows or old tires placed in the erosion channels to control soil loss. Another method is to cut tree branches and throw them on the soil surface to capture soil and encourage grass re-growth. Construction of spreader banks is a recent method that is used to reduce water flow and allow seepage, hence conserving soil moisture in the veld.

Modern methods include weirs built by the government along rivers and sluits for soil and water conservation. It was interesting however to note that some farms had weirs which were built more than 100 years ago, although weirs are viewed as modern. Figure 5.5 shows an example of one of the old weirs located in Murraysburg.

Figure 5.5 Old weir at Murraysburg (Source: S. Theron, personal communication)

Livestock farmers are also faced with challenges of feed shortage. Farmers purchased lucerne from neighbouring farmers to feed livestock during drought periods, while others even imported the fodder from other regions. Commercial farmers also stored lucerne fodder and hay to feed animals during the dry season. Alternative fodder sources have also been in existence for a long time in the Karoo. Saltbush (*Atriplex nummularia*), Agave (*Agave americana*), Prickle Pear (*Opuntia*) and Prosopis are fed to animals by some farmers, although mesquites (*Prosopis*) is considered as an alien species that needs to be eradicated.

5.6.3 Improving Survival and Productivity of Livestock

Livestock management strategies in the Karoo also included reduction in scale of production. Some farmers sold older and weaker animals and kept a more resilient herd. The decisions were based on long established ecological principles that seek to balance animal numbers and the available veld. As the conditions worsened some farmers sold most animals and leaving the breeding herd.

Some farmers have had access to a short term government financing scheme where farmers are asked to sell a percentage of their animals then the government compensates the farmer. The scheme is run on a voucher method, where for a certain percentage sold the farmer gets vouchers to buy feed for his remaining herd. The farmers are however not happy with the way the scheme is usually administered. It takes up to 9 months from the time of application to the time of approval for the fund. By that time the farmers would have lost a large portion of their herds. Most farmers would like the funding for such disasters to be decentralised and be readily accessible to them. This was also confirmed by the extension officers who also felt the scheme could work better if farmer concerns were taken into consideration. There is currently no reserve money for drought and drought preparedness is very low. Setting aside a disaster fund at provincial level would help farmers who currently use their reserves to buy fodder during drought.

Another strategy would be supplementary feeding of animals based on their condition. Supplementary feeding for ewes is done when they are ready for lambing. Most farmers plant lucerne and bale it for supplementary feeding during drought periods; sometimes the lucerne is kept for up to 5 years. Some farmers also buy lucerne from other farmers to pen feed the animals. Under extreme drought conditions some farmers might consider selling all the animals and bank the money to start farming when conditions are favourable and there is enough feed and water.

Livestock farmers described various ways in which they departed from normal practice during drought periods. The farmers usually have long term plans and solutions for drought. One farmer called it ‘farming with the veld’. The first strategy when drought begins is grazing management. O’Farrell et al. (2009) describe methods whereby farmers practice grazing strategies that rely on fenced camps and livestock rotation between the camps to ensure effective use and protection plant species that are susceptible to drought. This strategy was practiced by all interviewed livestock farmers. The time spent by the animals in the camps was also shortened to prevent prolonged damage to vegetation. Farmers also reduced stocking rate, for example from 6 ha/small livestock unit (SSU) to 10 ha/(SSU). This also allowed the veld to remain in good condition.

Farmers with access to more land implemented the avoidance strategy where they moved animals to other farms where there are wetter conditions with good grazing and available water until the conditions became favourable. One farmer described how his father and grandfather used to move with the animals to wetter areas, and they could travel for up to 6 weeks. In the 1960s the government provided train subsidies to farmers to move animals to wetter areas, for example from Outdsthoorn to the Free State. It was also common for farmers to own two farms, one in the dry areas and another winter Karoo farm where animals stayed from May to October. O’Farrell et al. (2009) also describe some of these strategies as being still in existence in the Karoo. The authors confirm that movement strategies in association with climate and vegetation responses are still evident in the commercial farming sector, although the strategies are now constrained by land ownership.

Farmers also changed their herds to more resistant animals, e.g. from Boer goats to Angora goats, or from Merino sheep to Dorpers as long term adaptation to the environment. Some farmers also diversified into game farming, e.g. springbok. Ostrich farming was also seen as an alternative activity during drought periods, although the ostrich industry is currently depressed due to the avian influenza.

5.6.4 Scheduling Activities

Scheduling of activities was very critical for livestock farmers. The lambing season and selling seasons were important times for every farmer, as these needed to occur when the veld condition was good. Table 5.6 shows the activity calendar for the Zoar smallholder farmers. The calendar activities were almost similar for all small stock farmers who produced dorpers for mutton.

Table 5.6 Activity calendar for small stock production – Zoar Community

Month	Activity
January	Graze in the fields Food and water available
February/March	Graze in the veld Lucerne production Gardening as an side activity
Before Easter	Lambs are sold to mobile buyers
April/May	Buy extra feed for winter
June	Day time grazing in the veld Lucerne/mealies pen feeding at night
July/August/September	Lambing period Extra care of animals Extra feeding for lambs
November/December	Selling period, lorry comes to buy, lasts 3-5 months Lambs sold 5-6 months old, 25-30 kg

There were slight variations with farmers producing Angora goats for mohair and Merino sheep for wool. The mating season occurred around April and lambing season was around September. The farmers carry out shearing in February and August.

5.6.5 Reducing Water Shortages

Livestock farmers are based in the driest parts of the Karoo in Beaufort West and Prince Albert. One farmer expressed that '90% of our problems are solved by rain', and the expression was concurred by one of the oldest extension officers in the Karoo. The major limiting factor in livestock farming is water. Farmers therefore heavily rely on ground water. When there is enough rainfall animals drink from rivers and weirs. Some traditional clay dams still exist in Zoar and animals still drink from them when there is enough rain.

Farmers in the Karoo have also devised long term water conservation methods in order to manage during drought periods. Permanent silt traps and sluits have been constructed in order to prevent dam siltation. Building contours along mountain slope is also an old system used to conserve soil and water. Farmers have also developed mountain slope water harvesting into stock dams, a system that is more than 100 years old in some areas. Windmill pumped boreholes can still be seen all over the Karoo, and these structures also date back hundreds of years. Boreholes are drilled in the veld and windmills are used to pump water into troughs from which livestock drink. In the past the government used to provide subsidies to farmers for windmills. The support is not available to newly re-settled making them more vulnerable to drought. Some farms also have a series of closed tanks in the veld for water storage.

5.6.6 Other Drought Management Strategies

Commercial farmers have seen the encroachment of invasive plants such as the cactus rainflower, satanbos (*Solanum elaeagnifolium*) and boetebos (*Xanthium spinosum*). Boetobos was a major problem. In addition to take up valuable veld the thorns of the plant get stuck into wool and that reduces the quality and price of the wool. The farmers are involved in active programmes to destroy invasive plants in collaboration with the

government which provides herbicides to the farmers. The traditional methods would have been to cut and burn the plants.
Farmers suffered heavy losses to lambs due to predators. Farmers used to wean the lambs in the veld but they suffered up to 15% losses due to predation by caracals. The bush pig (*Potamochoerus larvatus*) is also a new predator that has caused problems. The farmers are now weaning around the homestead instead of the veld. The Zoar community employs 3 herdsmen who are based fulltime in the veld. Their animals are put in kraals every night, hence they suffer minimal losses.

The Zoar community were using traditional plant medicine to treat animals in the field. The herdsmen still use the old methods inherited from their forefathers.

One farmer informed the researchers that he was using traditional methods combined with modern methods to do pregnancy tests on his ewes. He uses scanning to check the ewes and he is able to decide early in the season to sell the ewes while they are still in good condition.

CHAPTER 6: INTEGRATING INDIGENOUS/LOCAL AND SCIENTIFIC KNOWLEDGE

6.1 INDIGENOUS/LOCAL STRATEGIES AND SCIENTIFIC KNOWLEDGE

6.1.1 Introduction

Most studies on indigenous knowledge report on coping and adaptation strategies in one type of the agricultural system, e.g. climate change indicators/perceptions of drought (Cooper et at., 2008, Mubaya et al., 2012, Gandure et al., 2013, Kalanda-Joshua et al., 2013, Nkomwa et al., 2013, Li et al., 2013), indigenous knowledge around certain crops (IK on rice cultivation by Li et al. 2013) or IK on soils (Gray and Morant, 2003). The uniqueness of this project was in the effort to assess indigenous knowledge in the whole Karoo agricultural system, looking at crop, mixed and livestock systems. Information was collected under a variety of farming contexts with different kinds of activities at different levels of production. This complexity meant that the project could not go beyond documenting insights. The definition of indigenous knowledge had to be all encompassing 'traditional or local knowledge, that is embedded in the community and is unique to a given culture, location or society.' This was necessitated by the fact that the Karoo community is made up of traditional Khoisan communities, but at the same time the other communities have also been living in the Karoo since the late 1700s. The selected definition had to cover all these communities. The context was therefore so varied that the research could not adopt the livelihoods approach. One cross cutting theme of indigenous local knowledge could not be used for resource balances in the livelihoods frameworks. The project team advisers agreed that a better approach would be to focus on coping and adaptation strategies, as this allowed the data to be clustered into short term (coping) and long term (adaptation) strategies.

The project first identified typology around farmers and the farming systems in order to understand if the coping and adaptation strategies were clustered around farmer type or farming system. The farming system approach was adopted therefore the data/information was presented according to crop farming, livestock farming and mixed crop-livestock systems. There was need to develop another typology that would allow the project to compare the results with scientific knowledge. Through interactions with farmers and closely analysing the information new typology emerged around weather/drought indicators, changing farming practice, reduction in production level/scale, scheduling activities, water management/saving and soil and water management. This clustering allowed us to view the systems from all levels of production and well as all types of farmers and farming systems.

6.1.2 Scientific Proof of Aridity Occurrence in the Karoo

Scientific analysis of drought occurrence in the Karoo was done using climate data from four sites in the Karoo. Table 6.1 shows the number of days of the occurrence levels soil moisture stress in 4 sites in the Karoo.

Table 6.1 Soil water (days per annum) (Source: Prof R. Schulze, 2014, personal communication)

	Excessively wet	No stress	Mild stress	Severe stress
Beaufort West	3.30	27.20	27.06	307.68
Prince Albert	2.04	25.70	25.84	311.66
Calitzdorp	3.34	34.12	34.94	292.84
Oudtshoorn	2.50	32.86	36.20	293.68

The results indicate that the Karoo experiences soil water stress more than 75% of the time. Prince Albert experiences the least number of wet days and the largest number of days with severe stress. This is in line with discussions held with the farmers who said that that the Karoo is almost a desert.

Drought frequency was also analysed for the four areas and the results are shown in Tables 6.2 and 6.3, for one month and three month frequency.

Table 6.2 One month dry spell frequesncy (Source: Prof R. Schulze, 2014, personal communication)

	Mild dry spells per annum	Moderate dry spells per annum	Severe dry spells per annum
Beaufort West	3.86	2.4	1.5
Prince Albert	3.94	2.6	2.1
Calitzdorp	3.88	2.4	1.7
Oudtshoorn	3.88	2.3	1.2

Table 6.3 Three consecutive month dry spell frequency (Source: Prof R. Schulze, 2014, personal communication)

	Mild dry spells per annum	Moderate dry spells per annum	Severe dry spells per annum
Beaufort West	0.50	0.1	0.16
Prince Albert	0.48	0.16	0.16
Calitzdorp	0.36	0.06	0.04
Oudtshoorn	0.52	0.12	0

Mild dry spells of one month frequency are prevalent in all areas. Prince Albert once again was the most affected. These results are in line with the findings in the field. There was hardly any crop or lucerne production in the Prince Albert area. The most sophisticated drought monitoring equipment was found in orchards in the same area. Beaufort West and Prince Albert are both prone to severe three month droughts.

All farmers interviewed concurred that the 1960s had one of the worst droughts in living memory. Spatial and temporal analyses of drought done by Dent el al. (1987) confirmed the occurrence of severe long term droughts during the late 1960s and the period 1981-1983. There are a few other studies that compared indigenous knowledge methods of predicting drought with scientific knowledge in other countries. In Uganda, Orlove et al. (2010) reported that changes in overnight temperatures and wind direction that were reported by the farmers could be plausibly linked with the arrival of the Inter-Tropical Convergence Zone (ITCZ). Li et al. (2013) found that farmers had a good understanding of climate change and their perceptions were consistent with monitored climate data.

There is however no scientific knowledge that can be linked to indigenous knowledge drought indicators around animal behaviour and plant characteristics that were described by the Karoo farmers. This is valuable information that can provide valuable insights in areas where there is no access to scientific information. It was interesting that there was so much information sitting with the farmers, but not documented. This observation links with the comment made by the oldest extension officer; that only people who had lived in the Karoo for a long time could accurately tell by just observing the environment that a drought was approaching. Emerging farmers who have recently settled in the area would benefit a lot if some information on the environment that they settled in was freely available.

6.1.3 Comparison of Indigenous/Local knowledge with Scientific Knowledge

A comparison of indigenous/local knowledge systems with scientific knowledge was done using information collected from farmers and extension officers. Table 6.4 summarises the IK methods and gives corresponding scientific methods currently used in the Karoo and other regions (see also Table 5.3, 5.4 and 5.5).

Table 6.4 Indigenous knowledge and scientific snowledge

Typology	Indigenous/Local Knowledge	Recent Scientific Knowledge
Drought indicators/Early Warning Indicators	• Wind direction, Temperature changes, Low rainfall • Animal behaviour, Changes in plant characteristics	• Inter-tropical Convergence Zone (ITCZ) moving south • Weather prediction models • Rainfall records
Changing Practices	• Manure and compost to conserve soil fertility • Bottle/can dug in the ground to water vegetables through seepage • Cover crops to conserve moisture • Destocking to reduce herd • Migrating with animals to places with more grazing • Saltbush (*Atriplex nummularia*) for feeding livestock • Prickle pear (Opuntia) for feeding livestock • Agave (*Agave americana*) for feeding ostriches • Feeding mesquites (*Prosopis*) to livestock	• Use of chemical fertilizer • Drip irrigation • Sprinkler irrigation • Shade netting • Pen feeding pellets and purchased feed • Scanning for pregnancy to destock ewes • Creation of camps and rotating animals • Planting and storing lucerne to feed during drought
Reduction in production level/scale	• Planting and irrigating small areas • Destocking and keeping breeding herd	• Farmer decides on the focal enterprise and produces intensively • Destocking and keeping breeding herd • Alternative low input farming such as ostriches and game • Government voucher scheme provides funding to cover destocked animals and feed for the smaller herd
Scheduling activities	• Flood irrigation • Abandoning crop farming for other enterprises during drought	• Drip irrigation • Use of a series of probes to monitor soil moisture • During drought farmer irrigates a few hectares for production
Water Management	• Mountain slope water harvesting • Use of stock dams for water storage • Traditional water rights system	• Roof rainwater harvesting and storing water in tanks • Reliance on boreholes/ground water • Revised water rights system
Soil & Water Conservation	• Branches and stones to conserve soil • Contours and silt traps • Weirs along sluits for water storage and to capture silt	• Storm drains • Spreader banks in the veld • Gabions • Eradication of invasive plants
Other Resource Management	• Use of plants to treat animal diseases	• Use of modern medicines to vaccinate and treat animals

Hart and Vorster (2006) wrote a policy brief on the potential of indigenous knowledge for agricultural development in South Africa. The authors focused on the application of indigenous knowledge and local innovation at micro level of the farming household or community, giving seven case studies. The value of the briefing was in the way IK was presented and the similarity of some of the findings to smallholder farming systems in the Karoo, for example collective grazing management in Bergville, Kwazulu-Natal, which was similar to the Zoar Community system.

Farmers have also developed indigenous knowledge methods around soils in their environment. In Burkina Faso Gray and Morant (2003) reconciled indigenous knowledge with scientific knowledge and found that farmers' perceptions of soil types and characteristics matched well with scientific investigations. Farmers in the Karoo have developed and maintained a number of indigenous knowledge methods that they use to manage soil fertility and soil moisture. Subsistence farmers who cannot afford expensive fertilizer used organic manure and compost instead of chemical fertilizer to maintain soil fertility in the vegetable patches. The most innovative was the use of water bottles and tin cans to supply water to the root system. Commercial farmers used expensive equipment like drip irrigation systems to achieve the same effect. They also grew cover crops underneath the orchards to keep the soil cool and reduce evapotranspiration, while subsistence farmers used shade netting to achieve the same effect. Some farmers still used flood irrigation to irrigate lucerne, a system which is very inefficient in terms of water use. New scientific methods include drip irrigation, although sprinkler systems are still widely used. The farmers also use reliable soil moisture probes to schedule irrigation.

Farmers destocked most of their livestock in the 1960s if they could not afford to move the animals to better veld. In recent years farmers have been able to pen feed their animals due to the availability of feed such as pellets. Instead of destocking randomly some farmers use pregnancy scanning and only destock those ewes that are not pregnant. Previously farmers used to move from place to place in search of pasture for their animals instead of destocking. That is not possible now due to affordability and economic constraints which have negatively impacted multiple farm ownership. Farmers have learnt to conserve their veld through the creation of camps which are grazed in rotation, rested and allowed to recover from time to time, ensuring availability of veld for longer periods. Farmers also grow lucerne during good seasons and they bale and keep it for drier periods. Government subsidies have also ensured survival of the farming systems through the implementation of voucher schemes that compensate money for destocked animals which is used to purchase feed for the remaining herds. Some farmers also change to alternative methods such as ostrich farming and game farming which do not require a lot of water. Some crop farmers select one focal enterprise which does not require too much water such as vegetable seed production and they practice that until the drought season is over.

During previous droughts research was carried out to find alternative plant species that could be grown and fed to animals during drought. There is existing indigenous knowledge on how to utilise plant species such as saltbush prickle pear, Agave and mesquites to feed livestock. A visit to Oudtshoorn Agricultural Research Station research sites also found successful current research on these plant species. The District Manager for Central Karoo said farmers are showing renewed interest in these species and programs are now underway to distribute the plants to farmers.

Farmers who live along the Swartberg Mountains Valley have always had access to enough water even during drought periods. What makes the system successful is also the relationship between the smallholder farmers and commercial farmers. The farmers have a well-developed water rights system. Smallholder farmers have access to water from the large stock dams that have been built by commercial farmers and a well understood access rights system is followed. This worked very well in Matjiesrivier, but unfortunately it was not so in Swartrivier where emerging farmers were given land in 2010 and they are still fighting to gain access to irrigation water.

Soil and water management systems date back to the 1890s in the Karoo. Rowntree (2013) recently carried out a review on gulleys (sluits) dating back to the 1900s, and it appears erosion was once a big problem, but the gulleys have stabilised over the years. Most interviewed farmers also did not think soil erosion was a big problem but measures were in place to control it just in case it occurred. Indigenous methods of using branches and stones to conserve soil were still in existence. Old contours are still visible in mountains slopes of Oudtshoorn. Modern methods such storm drains, spreader banks in the veld and gabions are also used although most of these methods are now being implemented by the government through Landcare. A major activity meant to conserve the veld and soil moisture is the eradication of invasive plants. There is a combined effort between the government and farmers to deal with the problem of invasive vegetation in the region.

6.2 STRATEGIES WITH POTENTIAL TO BE INTEGRATED WITH SCIENTIFIC KNOWLEDGE

The overall aim of the project was to gain insights into indigenous coping strategies for drought adaptation in the Karoo. The first objective was to review international and South African literature on capturing indigenous knowledge around the experiences of drought in agriculture and its value for informing future planning. This objective was fulfilled in the first report. The second objective was to identify and capture any coping strategies (indigenous knowledge) adopted by communities in the agricultural sector for dealing with the 2009/10 drought and past drought experiences. This objective has also been fulfilled and the results were presented to the scientific advisers, extension officers and the Department of Agriculture management. The third and final objective was to identify measures that would ensure the resilience of the agricultural sector to future droughts through up scaling good indigenous practices into drought preparedness planning. The final section of this report therefore attempts to look at mechanisms for assessing vulnerability in agriculture and how farmer resilience can be further built in the Karoo.

Resilience is defined as the *ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions* (IPCC, 2012). In the project the hazardous event is drought, and the project therefore tried to identify measures that would ensure the resilience of the agricultural sector to future droughts in the Karoo, through up scaling good indigenous practices into drought preparedness planning. This process was done through a validation workshop and meetings with extension officers who work on the ground, the Disaster Risk Management Office, and the Directorate of the Western Cape Department of Agriculture. The results were presented and discussed in plenary. Some of the comments from the presentations were as follows:

- We relate to these indicators and we can also add chicken behaviour and the shape of the moon as the other indigenous indicators.
- Drought indicators are short term and are not really helpful in the Karoo as they will be visible when the drought has already started thus will be a bit late to take any measures.
- We appreciate that the project will publish Karoo indigenous/local knowledge that is not recorded anywhere, and the fact that this knowledge is very significant and useful to the farmers.
- The Disaster Risk Management department is currently compiling a drought contingency plan for the Western Cape, which will take about 2 years to complete. The plan will benefit a lot from the results of this project.
- The project is very useful and the knowledge should be transferred to new farmers. However, the best people to share the information are the farmers themselves, research and extension can facilitate the process.
- We are very impressed with the presentation and the research has brought so much into light and it would be of great interest if the report is shared or better yet if the research is furthered as it would be beneficial to the Cape Winelands and other regions.

The workshop participants were divided into four groups and they were also asked to answer two questions. The first question was ‘What should drought preparedness include in the Karoo region?’ Table 6.5 shows responses.

Table 6.5 Response to the question: What should drought preparedness include in the Karoo region?

Landcare and Extension Officers	Disaster Risk Management
• Fodder management/storage • Stocking rate and carrying capacity • Planting of crops that are adapted to drought • Planting drought tolerant and multipurpose fodder plants, e.g. prickle pear • Conservation farming/agriculture • Awareness raising and passing indigenous knowledge to farmers • Early warning systems	• **Funding for:** disaster management, capacity and mitigation fund, incentives and awareness. Involvement of relevant departments • **Formalized planning for:** Contingency drought plan, the completion of a comprehensive drought risk profile • **Risk reduction:** by means of awareness raising, drought management task force, adaptive land-use strategies, drought action plan

The participants were also asked to answer the question; 'Which strategies should research focus on, in order to improve the livelihoods of emerging farmers and why?' The participants gave strategies and research areas which they said should apply to all farmers:

- Long term early warning and accurate weather/climate forecasts
- Planting more drought-resistant fodder plant species
- Research on drought-resistant crops
- Conservation agriculture

The workshops identified priority research areas for the region that could assist in building farmer resilience against drought. The question is 'How does the information/data gathered in this project fit with scientific knowledge?" The big challenge is in taking forward the work which all stakeholders agree is very useful for the Karoo region and beyond. There are three ways to build resilience; reducing exposure, reducing sensitivity of systems to shocks (e.g. drought), and increasing adaptive capacity through modification of a system (Gitz and Meybeck, 2012). Extension officers recommended that focus should be placed on reducing drought impacts (reducing sensitivity) and improving long term adaptive capacity of the farmers. Improving extension understanding in integrating scientific and indigenous knowledge will ensure that this becomes a reality.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The focus of the project was to get insights on how farmers in the Karoo have built resilience against drought over the years based on experiences of the past droughts. A number of conclusions were drawn from the research findings.

There is vast literature on indigenous knowledge as shown by the literature review. Collecting so much literature however made it difficult to narrow down the research. The project initially focused on every aspect of water and agriculture and every type of farmer and farming system, which made it difficult to develop typology under which indigenous knowledge could be documented. The classification of farmers in the Karoo was not easy. The Department of Agriculture definitions of subsistence, smallholder and commercial farmer do not fit with the characteristics of many farmers in the Karoo. There is a range of sizes and types of farms, including the recently resettled emerging farmers, and most of them do not fit the definitions. Blanket definitions could result in unique farming systems being missed by research. Using farming systems and activities however gave a better overview of the farmers; hence indigenous/local knowledge was classified according to the identified farming systems (crop, mixed-crop livestock and livestock). This approach allowed the project to further classify the local/indigenous practices in terms of coping and adaptation to drought.

There is a rich local indigenous knowledge base in the Karoo. The knowledge sits with every farmer, despite race, origin or resource endowment. The research targeted all types of farmers and the result was a detailed list of indigenous coping and adaptation strategies for the region. The identified strategies match with the IPCC lists of adaptation strategies and actions (Table 2.1). Farmers involved in horticulture have developed strategies to conserve water, and they are able to grow vegetables throughout the year. Crop-livestock mixed systems have also developed strategies to cope with water shortage. They have also set up their systems in such a way that they are able to switch their focus to either livestock or crops depending on the conditions. During severe drought the farmers focus more on livestock which does not require a lot of water, but they also set up small areas of high valued vegetable seed crops. During normal seasons they grow pasture crops and store fodder to feed animals during drought periods. Livestock farmers have learnt to manipulate grazing lands so well that they are able to cope even during severe droughts. However despite all knowledge there were some farmers who did not seem to be well prepared to cope and adapt to drought, especially emerging farmers who were struggling to get access to water for irrigating pastures.

The outcomes of the validation workshop and meetings reiterated the need to have an indigenous knowledge base that farmers can share in the Karoo. Extension officers also identified the need to carry out further studies on early warning systems and accurate weather/climate forecasts, planting more drought-resistant fodder plant species, research on drought-resistant food crops and conservation agriculture as some of the strategies that would improve the adaptive capacity of farmers against drought. The project outcomes also link to current priority areas for drought preparedness in the Western Cape; hence the research team has been identified as a key contributor to the Western Cape Provincial Drought Plan.

7.2 RECOMMENDATIONS

7.2.1 Documentation of Indigenous/Local Knowledge

One of the main objectives of the research was to document drought coping strategies adopted by farmers in the Karoo. This objective was achieved. A data set of drought impacts, indigenous/local coping and adaptation strategies has been generated and it is presented in this report. The end users of this information are the farmers themselves and the policy makers. There is need to package this information in a form that all farmers can have access to. This has been discussed and with extension officers and the Department of Agriculture in the Western Cape. Suggested methods of sharing the data include the following:

- Share the results with farmers in workshops and during information days via presentations by the research team
- Package the results into information brochures that can be distributed to farmers
- Develop a policy brief targeted at policy makers in central government and the Western Cape Province
- Decentralization of information using cell phones

7.2.2 Improving Extension Understanding of Indigenous Knowledge

Closely linked to information sharing is training for extension officers. It is assumed that extension officers understand local/indigenous knowledge, but do they value the contribution of the knowledge in improving farmer livelihoods? Incorporating indigenous knowledge into extension activities will allow extension to work closely with farmers when farmers realise that their knowledge is valued. There is a need to explore opportunities for training extension officers in farmer participatory approaches that will enhance local indigenous knowledge practice in terms of coping and adapting to drought.

7.2.3 Improving Farmer Resilience in Coping and Adapting to Drought in the Karoo

The research project provided insights into farmer strategies in coping with drought in the Karoo. The project also proved that this information sits with individual farmers and there is no mechanism to share. In addition the question of how indigenous knowledge can be integrated into scientific research has not been answered. There is need for follow-on research to cover some of the identified gaps. Extension officers already provided some of the areas that need to be further researched. The list included the following:

Long term early warning and accurate weather/climate forecasts
The need to have accurate weather and climate forecasts is very important in the Karoo, where most of the time it is not easy to realise that drought is approaching due to the already semi-arid nature of the environment.

Planting more drought-resistant fodder plant species
The need to have fodder banks to save animals during drought was very clear. However, it is not clear which fodder species are appropriate for long term storage, how long the fodder can be stored, even how it should be stored using indigenous locally available materials.

Research on drought-resistant crops
A lot of drought-resistant varieties of maize, sorghum, millet, groundnut and many other food crops have been released in recent years and they are available for trial in different regions. Extension officers recognise that there is a need to introduce some of these crops to farmers to increase options for food production. Crop production is currently done by large commercial farmers only in the Karoo. Newly resettled farmers are keen

to become commercial farmers too. There is need to explore methods of introducing some of these crops to farmers especially smallholder emerging farmers.

Conservation agriculture

Conservation agriculture is seen as one of the ways of improving food production in the smallholder farming sector because of its low input requirements. The system is successful in some parts of Southern Africa. This is technology worth trying in the Karoo in combination with some of the identified strategies such as the use of manure, composting and mulching.

7.2.4 Programmatic Support for Emerging Farmers

Initial engagement with emerging farmers through other research in the Breede-Gouritz Catchment Management Agency (BGCMA) indicates a lack of support for emerging farmers in sustaining their livelihoods in the newly resettled areas. There is need to engage with emerging farmers in order to develop programs targeted at improving their livelihoods and increasing their adaptive capacity against droughts.

7.2.5 Sustainable Livelihood Frameworks and Integrating Indigenous Knowledge with Scientific Knowledge

The research project had proposed that the concept of 'sustainable livelihoods' (SL) would be used as a framework for supporting adaptations in conjunction with the Learning about Livelihoods (LAL) framework (de Satgé et al., 2002). A livelihood comprises capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base (Scoones, 1998). The information collected in the project did not cover assets; therefore the proposed frameworks could not be applied. This is a gap that needs to be filled by follow-on research. This information will also be used to explore if the process framework by Mercer et al. (2010) that was proposed at the start of the project can be applicable in the integration of local indigenous and scientific knowledge.

7.2.6 Creating Linkages

The project has created linkages and collaboration with important stakeholders who are interested in the research results, and others who would like the work on indigenous knowledge. The research team is already part of the group of stakeholders that will provide input into the Western Cape Provincial Drought Plan that the Disaster Management and Provincial Department of Agriculture are in the process of updating. A close working relationship was also created with the Western Cape Department of Agriculture from the Chief Director, District Managers to Extension Officers. There is need to create more linkages especially with the Breede-Gouritz Catchment Management Agency (BGCMA) who are already working with the research team on other livelihood projects.

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APPENDIX I – ARCHIVING OF DATA

1. Community Water Supply and Sanitation Research Unit

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The Community Water Supply and Sanitation Research Unit has a system of archiving project data that sits in a central server within the unit. All the field reports and project deliverables are filed in this system. The research unit also has a resource centre where hard copies of deliverables and the final report will be kept.

2. Cape Peninsula University of Technology

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The university has a records and archives department that keeps all university information and records. When the project is finalised all the deliverables and the final report will be sent to the department for archiving. Published reports and journal papers will be sent to the library for public access. Some of the reports will also be made available via the university website. Project communication is currently in a separate folder in the principal researcher's mail box. The university periodically archives all emails within the university email system.

3. Water Research Commission

The Water Research Commission has its own system of archiving all the reports submitted under projects. All deliverables are currently downloadable via the fund management system. In addition the final report will be published in hard copy form as well as in electronic form for public access via the knowledge hub. Web address: http://www.wrc.org.za/

APPENDIX II – TECHNOLOGY TRANSFER AND KNOWLEDGE SHARING

1. Documentation of Indigenous/Local Knowledge

The first objective of the research was to document drought coping strategies adopted by farmers in the Southern Cape. A data set of drought impacts, indigenous/local coping and adaptation strategies has been generated and presented in the final report. The end users of this information are the farmers and the policy makers. There is need to package this information in a form that all farmers can have access to. This has been discussed and with the Department of Agriculture in the Western Cape. Suggested methods of sharing the data include the following:

- Share the results with farmers in workshops and during information days via presentations by the research team
- Package the results into information brochures that can be distributed to farmers
- Develop a policy brief targeted at policy makers in central government and the Western Cape Province

2. Improving Extension Understanding of Indigenous Knowledge

The results were shared with extension officers through a validation workshop which was held on the 17th September 2014. The officers were given opportunity to comment on the results and fill gaps where they felt there was missing information. The research team will further engage with extension in future.

Training of extension officers in order to increase their understanding of local/indigenous knowledge is required to increase the value of the contribution of the knowledge in improving farmer livelihoods. Incorporating indigenous knowledge into extension activities will allow extension to work closely with farmers when farmers realise that their knowledge is valued. There is need to explore opportunities for training extension officers in farmer participatory approaches that will enhance local indigenous knowledge practice in terms of coping and adapting to drought.

3. Improving Farmer Resilience in Coping and Adapting to Drought in the Karoo

The research project provided insights into farmer strategies in coping with drought in the Karoo. The project also proved that this information sits with individual farmers and there is no mechanism to share. There is need for follow-on research to find ways of increasing uptake of coping and adaptation strategies. Extension officers provided some of the areas that need to be further researched in conjunction with indigenous knowledge studies. The research areas include the following:

Long term early warning and accurate weather/climate forecasts
The need to have accurate weather and climate forecasts is very important in the Karoo, where most of the time it is not easy to realise that drought is approaching due to the already semi-arid nature of the environment.

Planting more drought-resistant fodder plant species
The need to have fodder banks to save animals during drought was very clear in the research. However, it is not clear which fodder species are appropriate for long term storage, or even how the fodder should be stored using indigenous locally available materials.

Research on drought-resistant crops
A lot of drought-resistant varieties of maize, sorghum, millet, groundnut and many other food crops have been released in recent years and they are available for trial in different regions. Extension officers recognise that there is a need to introduce some of these crops to farmers to increase options for food production. In some areas there may be need to revert back to indigenous legumes such as cowpea and Bambara nut in order to increase farmer resilience to drought.

APPENDIX III – CAPACITY BUILDING

1. Individual Capacity

The project started with Mr Amin Benjamin as the principal researcher and PhD student. However, he left the project in the middle stages. The other students from the unit were Ms Amanda Gcanga who left the country for studies overseas, and Ms Rachel Mweri who also left the research unit. Although the three left the project, their contribution in the early part of the project was substantial. Ms Gcanga was granted sabbatical leave to complete a Masters Degree at Wageningen University and she has returned to the team and will now go on to register for a PhD.

The principal researcher was replaced by Dr Bongani Ncube an experienced researcher who continued to work with the Project Leader Prof Lagardien and Mr Christophe Muanda. Two other MSc students Ms Monique Natus and Ms Phakama Amos were also recruited into the project during the third year. Unfortunately Ms Natus moved to a different project due to her research interests, while Ms Amos decided to leave the studies due to personal circumstances. A student from another project Ms Sinazo Mnyaka has been assisting in the project since the departure of Ms Amos and she is registered for a Masters degree and will continue in the team.

All the students expressed gratitude for the experience that they gained in the project through data collection, farmer participatory research and project report writing. Ms Gcanga has returned into the research unit with an MSc focusing on irrigation water management for smallholder farmers, knowledge which the unit will utilise in further research work.

2. Organisational Capacity

The Community Water Supply and Sanitation (CWSS) Research Unit has benefited a lot from the project through capacity building and increased research capacity. The recruitment of Dr Ncube into project resulted in an expanded research focus in the unit. A niche area of water and agriculture is under development and more projects are being initiated under this theme. In addition linkages were established with Wageningen University through the project, and it is envisaged that more students will be trained in agricultural water management through research collaboration. With the return of Ms Gcanga institutional capacity has increased in this area.

Dialogue with the Department of Agriculture at all levels has resulted in a better understanding of indigenous knowledge systems in the Southern Cape and the potential of the knowledge to uplift the lives of farmers. Participation in the project resulted in increased research capacity in the department of agriculture. Mechanisms of sharing the project results with the farmers have been discussed at the highest level (Chief Director) in the Department of Agriculture in Western Cape, and uptake of the findings through new research has been discussed. The established collaboration with the Extension and Landcare officers is likely to cascade down to the farmers and the adoption of some of the discussed coping and adaptation strategies will improve resilience in the agricultural sector especially emerging farmers and the historically disadvantaged groups.

The results of the project are feeding into the Western Cape Provincial Drought Plan. The research team has been asked to provide input into the drought plan and meetings are lined up in December and early in the New Year.

3. Community development

Farm visits, interviews and focus group discussions on indigenous local knowledge stimulated new zeal for indigenous knowledge systems among all types of farmers. Emerging small-scale farmers and subsistence farmers particularly recognized the potential of indigenous knowledge in coping and adapting to drought. Although the project was seeking insights some of the sessions ended up becoming knowledge sharing opportunities among extension officers, the research team and the farmers. There is potential to upscale some of the identified coping and adaptation strategies.

The identified best indigenous farming practices for coping with droughts will inform future livelihood projects in agriculture to consider traditional practices in ensuring resilience to future anticipated droughts. The department of agriculture is keen to see the results shared with farmers at grassroots level, a positive outcome of the project.