Towards understanding the impact of Climate Change on livelihoods, local knowledge and agriculture-based Climate Change coping practices of small-scale farmers of the Ebenhaeser community

By

Mateus Costa Santos 3174998

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Supervisor: Dr. Lionel Thaver

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This study is dedicated to you.

ABSTRACT

Climate Change (CC) is arguably the most pressing topic of our modern society. The acceleration in magnitude and frequency of climate variability associated with it, along with the overall change of climate patterns threatens to push their adaptive capacity to breaking point, hinting at the significant impact that CC will have on the livelihoods of small-scale farmers of the developing world, and on South Africa in particular.

This research project aims to investigate how local knowledge and agriculture-based coping practices of small-scale farmers of the Ebenhaeser community are adapted to deal with and attempt to reduce the vulnerability of their livelihood strategies to CC. This illustrative study followed a qualitative methodology, using qualitative data collection (in-depth and semi-structured interviews, as well as special focus group discussions) and analysis (thematic ordering) methods to fulfil its aim.

This study revealed that local farmers were able to identify changes in climate which were hazardous to their livelihoods and that they have been developing coping practices in response the CC. Furthermore, this analysis showed that local small-scale farmers used their local body of knowledge as a basis for the development of these coping practices, and that this local knowledge base itself has been affected by CC.

An important finding of this study was the extent to which local social, historic, economic, political and physical conditions influence the sensitivity and adaptive capacity of the small-scale farmers of the Ebenhaeser community. The findings of this study opened our eyes to the realities of CC and its impacts on and adaptation efforts of small-scale farmers of the Ebenhaeser community. The study show ed that unless these issues are addressed in a comprehensive and holistic manner, there is no real prospect of sustainable, long-term CC adaption solutions for the small-scale farmers of this area, and conceivably none for many more rural communities in South Africa.

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CHAPTER 1

STRUCTURE AND ORGANISATION OF STUDY

1. BACKGROUND

Climate Change (CC) is arguably one of the most pressing topics of our modern society. It is felt by every single person f in this world, and it poses some of the toughest challenges to mankind, since it is so intricately connected to the ways in which we have achieved our current levels of development as a society (UNFCCC, 2012b).

Nevertheless, the impacts of CC are not evenly distributed (Kirkland, 2012), and there is general consensus that due to their continuing reliance upon resource-based livelihood strategies, indigenous populations and marginal communities, including rural small-scale farmers, are the most vulnerable to such impacts (Intergovernmental Panel for Climate Change (IPCC), 2007; Nakashima, Galloway McLean, Thulstrup, Ramos Castillo, and Rubis, 2012; David, 2009). Indeed, most climate change models predict that the damage will be disproportionately borne by small-scale farmers, particularly rain-fed agriculturalists in the Third World (Altieri and Koohafkan, 2008).

Climate Change not only affects the two most important direct agricultural production inputs – precipitation and temperature (Deschenes & Greenstone, 2011, cited in Nakashima *et al.*, 2012) – but also poses indirect threats to agriculture by influencing emergence and distribution of crop pests and livestock diseases; exacerbating the frequency and distribution of adverse weather conditions; reducing water supplies and irrigation; and enhancing severity of soil erosion (Watson *et al*. 2008, cited in Nakashima *et al.*, 2012; IPCC 2010). These changes are expected to have a strong impact on South African small-scale farmers (Financial and Fiscal Commission, 2012: 66). Although farmers are traditionally able to cope with

seasonal climate variability, the acceleration in magnitude and frequency of these, along with the overall change of climate patterns threatens to push their adaptive capacity to breaking point (Nakashima *et al.*, 2012). Social and economic problems magnify such climate impacts (Kirkland, 2012).

Studies conducted aimed at understanding local CC coping practices have demonstrated that small-scale farmers respond actively to the challenges posed by climate change and variability (Srinivasan, 2004), and their ability to respond to changing climate conditions is determined by their capacity to develop CC coping practices (Kirkland, 2012). Such responses are most often based on the local knowledge bodies of the small-scale farmers themselves and that of the wider community, and include coping options such as diversification on and beyond the farm and migration, and above all, making changes in farming practices and technology to cope with unforeseen changes in climate (Below, Artner, Siebert and Sieber, 2010).

It is against this background that the researcher conducted this project, with the aim of understanding the relationship between the impact of CC on small-scale farmers of an impoverished community in the Western Cape Province, the Ebenhaeser community, and the development of local knowledge-based agriculture-related CC coping practices.

In the following sections of this chapter the researcher presents the aims and objectives of this study, its problem statement and research questions, as well as an overview of the methodological approach and design of the research. Finally, the researcher discusses the significance of this study and provides a chapter outline of the complete research report.

2. PROBLEM STATEMENT, RESEARCH QUESTION, AIMS AND OBJECTIVES

2.1. Problem Statement

Small-scale farmers engage actively with their natural environment and as such have accumulated sizable and sophisticated bodies of knowledge and practices about their environment, its variability and transformation. This knowledge and know-how provide the basis for their livelihoods (Nakashima *et al.*, 2012). However, the acceleration in magnitude and frequency of climate variability, along with the overall change of climate patterns linked to CC threatens to push their adaptive capacity to breaking point (*ibid*). This situation hints at the significant impact that climate change will have on the livelihoods of small-scale farmers of the developing world, and in South Africa in particular (Madzwamuse, 2010: vi).

Nonetheless, research has shown that small-scale farmers around the world are already developing and implementing creative local knowledge-based solutions to reduce their livelihood vulnerability to CC and climate variability, and do so within a context of social and economic pressures that influences the appropriateness of such responses, and often exacerbates their vulnerability (Kirkland, 2012; David, 2009; Abeka, Anwer, Bhatt, Bii, Muasya, Rozario, Valverde and Vilchez, 2012). Furthermore, the most common coping practices by traditional communities have involved adjustments required to adapt their livelihoods to changing climatic conditions (Galloway McLean, cited in Nakashima *et al.*, 2012).

There is limited information on the coping practices being used by South African small-scale farmers to reduce their vulnerability to CC, and the appropriateness of these coping practices in doing so. Even less is available on the dynamics of the process of development of local-knowledge-based CC coping practices of these farmers in the country as a whole, and in the

Ebenhaeser community in particular. This opens up new avenues for research, motivating the problematic of this study.

2.2. Aim of the Research Project

This research project aims to investigate how local knowledge and agriculture-based coping practices of small-scale farmers of the Ebenhaeser community are adapted to deal with and attempt to reduce the vulnerability of their livelihood to CC.

2.3. Research Questions and Objectives

2.3.1. Research Questions

Within the context of the research problem identified above, the researcher will attempt to provide an answer to the following research questions:

- How has the community experienced changes in the climate over the most recent past years?
    - What impact did these changes have on farming conditions and on farming produce? Have local farming practices been modified or adapted? If so,
    - What changes were made?
    - How and why were these changes made?
    - What effect did these coping practices have on key livelihood resources?
- What local knowledge did the community draw on?
    - What was effective?
    - What adaptations to local knowledge had to be made?
    - Were these adaptations effective?
- What impact has CC had on the key livelihood resources of small-scale farmers of the Ebenhaeser community?

- How has this impacted on livelihood strategies of small-scale farmers in the community?

2.3.2. Research Objectives

The specific objectives of this research project are:

- To document local knowledge of climate conditions and the effects of climate change, as well as document local knowledge about agricultural practices and related effects of CC, with a view to identify and describe the local knowledge-based agriculture-related CC coping practices being developed by small-scale farmers in the Ebenhaeser community;
- To identify and describe the impacts of climate change on the livelihoods of small-scale farmers in the Ebenhaeser community, in order to assess their level of vulnerability to CC, with a view to investigate factors that exacerbate the vulnerability of local small-scale farmers' livelihoods to CC;
- To provide an analysis of the impact of CC on the key livelihood resources of the small-scale farmers of the Ebenhaeser community as it is mediated by the local knowledge and agriculture-based coping practices.

2.4. Significance of Study

This study will expand the body of knowledge on local climate change coping practices of small-scale farmers in the Ebenhaeser community by empirically exploring the dynamics of the process of development of local knowledge-based coping practices of small-scale farmers of the Ebenhaeser community aimed at reducing the vulnerability of their livelihoods to CC. This knowledge will serve as a stepping stone for the development of appropriate locally-based CC adaptation policy responses for the Cape West Coast.

3. RESEARCH DESIGN

This research study used an exploratory case study research format, following a qualitative methodology, and using qualitative data collection (in-depth and semi-structured interviews, as well as special focus group discussions) and analysis (thematic ordering) methods. A detailed discussion around the research methodology used in this study is presented in Chapter 6 Transport and other data collection logistics of the study were facilitated by the Surplus People's Project, the Ebenhaeser and Papendorp Information and Development Centre (EPIOS) a local community-based organisation, as well as by the researcher himself.

4. LIMITS AND LIMITATIONS OF STUDY

The generalization of results and conclusions of this study will not necessarily be valid in other ecosystems and social contexts similar to those of the Ebenheaser community, although, as is the case with qualitative studies, certain theoretical generalisations relating to the conceptual framework may be probable. The study is further limited by the small number of interviews, thus serving as an illustrative study of the dynamic initiated by the complex chain of CC, local knowledge, adaptive capacity and key livelihood resources within the constricts of the Ebenhaeser community. As such, this study is not reflective of the wider Ebenhaeser community, but can nevertheless be used as a way to understand the issue, offering a basis for comparative studies of a similar kind around the world.

5. ETHICS STATEMENT

The use of ethics in research not only satisfies a scientific moral code, but also leads to better scientific results because the adherence to ethical research practices leads to more attention to

the details of scientific research (University of Pittsburgh, 2011). Also, the credibility of science with the general public depends on the maintenance of the highest ethical standards in research (*ibid)*.

In order to adhere to research ethics principles, researchers are obliged to apply the some key values in their research, including s**ocial responsibility,** meaning that researchers should be attuned to the needs and problems of local and national communities in which they are functioning, as well as of the international community; **Justice,** referring especially to the fair treatment of the individuals or institutions concerned; **Benevolence,** meaning that all parties involved should not only be protected from harm, but efforts should also be made to ensure their well-being, increase possible benefits and reduce possible harm; **Respect for the individual,** meaning the duty to recognize the autonomy of the individual, and the duty to protect persons with reduced autonomy; the principles of **Integrity**, **Quality** and **Accountability** should also be observed ; **Informed consent**, meaning that participants should give informed consent, to the extent that they are capable; the **Right of Withdrawal**, guaranteeing that respondents participate in a voluntary basis and are free to withdraw from interviews whenever they please; and finally, the principle of **Confidentiality**, which refers to the fact that the researcher is obliged not to share this information with others without the participant's permission (University of Pretoria, 1999).

This study was conducted after the research proposal had been approved by the Senate of the Institute for Social Development and the University of the Western Cape. Permission to conduct the research was requested from the target community, as well as from the host institutions by means of the Informed Consent forms provided by the University. The researcher took the responsibility of ensuring that all gathered information was treated sensitively and confidentially. Consent forms, as well as a research information sheet and the

interview guide can be found in the annexure section of this study. The researcher also undertakes to submit the research findings to all relevant bodies.

6. TENTATIVE CHAPTER OUTLINE

Chapter One: Introduction and Background – This chapter introduces the study as well as giving some background information on climate change and its effects on small-scale agriculture with specific reference to the South African context. It also outlines the structure of the study, its aims, goals and objectives as well as a short overview of the rest, including items such as the research objectives and the research plan (including data collection and analysis).

Chapter Two: Literature review – This chapter provides a theoretical foundation for the study which is based on the analysis of local knowledge in the development of rural climate change adaptation strategies, as well as covering some examples of studies conducted on the issue. An outline of the profile of the target community is also provided.

Chapter Three: Research Methodology – Here, the researcher identifies and explains the research methodology used in this research project, including what instruments were used, for example, data collection and data analysis, and how these were conducted and operationalized, and finally, how the different steps of the research process were brought together to effect its findings.

Chapter Four: Data Presentation – This chapter of the study shows how the data collected are described, organized and sequenced, whilst studiously keeping clear of any attempts at analysis.

Chapter Five: Data analysis – In this chapter, the researcher presents the analysis of the data collected - using thematic analysis, in order to explore the cycle or circuit of CC, local knowledge, agriculture-related coping practices and key livelihood resources.

Chapter Six: Findings and Conclusions – In the final chapter, the researcher presents the overall findings of the study in relation to how the impact of CC on the local knowledge and agriculture-related coping practices of small-scale farmers in the Ebenhaeser community is experienced in relation to their key livelihood resources.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL/THEORETICAL FRAMEWORK

1. INTRODUCTION

A wide range of research has been undertaken in recent years due to the rise in prominence of CC as a serious issue, ranging from scientific meteorological and geographical studies, to solar irradiance studies, to studies on approaches to CC mitigation and adaptation. The multidisciplinary nature of studies on the impact of CC on the livelihoods, local knowledge and coping practices of small-scale farmers around the world (such as the Ebenhaeser community) means that they often draw on concepts from different fields of science. As such, in this section the researcher draws on concepts from scientific fields such as climatology research, social sciences and agricultural sciences to review some of the critical literature relating to the research topic. Here, key concepts pertinent to the complex of CC and its bearing on rural livelihoods are clarified. This is followed by an analysis of relevant evidence of small-scale farmers' vulnerability to CC, and the dynamic process of the development of CC coping practices by small-scale farmers in different contexts around the world. Finally, the conceptual/theoretical framework is presented which is distilled from this literature review and guides this research process.

2. LITERATURE REVIEW BACKGROUND

Contrary to common belief, a wide spectrum of views exists on the causes and the very existence of CC as a global issue, ranging from "alarmists" to "deniers". Indeed, the distance between these differing views is so great that it has been said that the only thing that is agreed on is that the earth's atmosphere is unique and that its greenhouse effect is fundamental for life on Earth (Sevá, 2011).

On one end of the spectrum are the so-called alarmists, mainly bringing forward the view that climate change is a purely manmade (anthropogenic) phenomenon and has the potential to kill us all and end humanity as we know it (Marshall, 2007). This view was made popular by Al Gore's documentary "An Inconvenient Truth"(2006) which expresses the view of climate change that is most widely propagated by mainstream media. It is also the view supported by the United Nations Framework Convention on Climate Change (UNFCCC), which is the official organ determining the development of climate change policy at international level. The UNFCCC defines climate change as "*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*" (UNFCCC, 2012a).

At the other end of the spectrum are the climate change deniers. This group includes scientists, climatologists, physicists, professors and general sceptics and contests the general understanding of climate change and its causes, with claims disputing a wide range of generally "accepted" views on the scientific veracity of the manmade CC theory. One of the more solid claims being made by this group is that climate change is a natural phenomenon mainly brought about by solar activity cycles (Marshall, 2007).

Somewhere in the middle are those who question the generally "accepted" views on CC, focusing on issues ranging from the appropriateness and accuracy of CC models to accurately predict future CC to the political overtaking of the climate change issue as a whole (Sevá, 2011; Marshall, 2007). The latter group's arguments have become louder in recent years in the wake of a series of events dubbed Climate gate 1 and 2. These events consisted of leaks of hundreds of emails and documents between scientists of various Climate Research Units linked to the UNFCCC showing gross misrepresentation of data, withholding other data and even attempting to destroy material subject to a freedom of information request in the lead up to the 15th and 17th UN Conference of the Parties (COP), respectively, (Miller, 2011). Another important claim coming from this side of the debate is that the political debate on the topic has been overrun by an over-emphasis on the environmental crisis, steering the discussion away from the political, economic, moral and cultural crisis that preceded it (Furtado, 2007). This is also the view of many social movements around the world fighting for social and climate justice. Although there is great value in these discussions, it is the view of the researcher that covering them in detail falls outside the scope of this research.

These dynamics play themselves out in many complex ways interacting with various aspects of society, at all levels of the political, social, and economic systems. Ultimately these complexities end up delaying, and in some cases even stalling progress in relation to taking proactive action to support small-scale farmers, fishermen and herdsmen (already some of the most vulnerable social groups) in coping with and adapting to CC.

3. WHAT IS CLIMATE CHANGE?

In order to understand how these dynamics play out, it becomes important to understand what CC is and how it interacts with the various other dimensions of the livelihoods of small-scale farmers.

The first section of our Literature Review Chapter focuses on the aspects mentioned above by covering various key aspects of CC, starting with definitions of climate, climate variability, CC, as well as the main expected effects worldwide at Southern African levels, as well as at national, provincial, and local levels.

3.1. Climate defined

Before going into the definition of CC it is necessary to have a look at what climate is in order to better understand the concept of CC and how it impacts the livelihoods of small-scale farmers.

According to Gruza and Rankova (2004: 1), **weather** is defined as the physical state of the atmosphere at a given point of the globe at a given time, and is characterized by weather elements such as air temperature, wind velocity, humidity, precipitation, solar radiation, clouds, and phenomena such as fog, hoarfrost, hail, and other weather variables (*ibid*). **Climate** on the other hand, is usually defined as the "average weather", and is represented by a set of weather conditions in a given spatial area over a given time interval. It is characterised using a statistical description in terms of means, extremes, variability indices for certain parameters, and frequencies of events over a given time period. The oscillation of these climatic variables can be classified according to various time scales, ranging from fractions of a second to several decades (Gruza and Rankova, 2004: 1-2). Within the context

of CC, the term climate is also used to denote the global climate, which is characterized by a set of states of the global climate system during a given time interval.

Also of interest to this study is the conceptof **climate variability,** which refers to variations in the mean state and other statistics of the climate (such as standard deviations and the occurrence of extremes.) on all temporal and spatial scales beyond those of individual weather events (Levina and Tirpak, 2006: 25). Climate variability is usually measured in intervals equal to three decades (which is the standard interval adopted by the World Meteorological Organisation), although it is reasonable to introduce additional groups of time scales within this space (WMO, 2012; Gruza and Rankova, 2004: 2). The unusual increase of current climate variability around the globe is also closely linked to CC.

Over many decades small-scale farmers have gained substantial knowledge on local climate conditions such as rainfall and temperature patterns, using this knowledge to develop reliable indicators (such as combinations of plant, animal, insect, and meteorological and astronomical indicators) which they used in order to make decisions about crop and irrigation cycles (Rengalakshmi, 2008: 1-3). This knowledge also serves as a basis for the development of various climate-related coping practices in rain-fed farming systems across the world. However, increasing climate variability linked to CC had the effect of reducing small-scale farmers' confidence in traditional knowledge to understand weather and climate patterns, increasing the vulnerability of their livelihoods to CC (*ibid*).

3.2. Climate Change defined

Climate Change is seen within the context of this study as referring to *[...] any change in climate over time, whether due to natural variability or as a result of human activity that persists for an extended period, typically decades or longer. Its most common indicators are*

temperature and precipitation, and it is closely linked to an increase in ***climate variability*** (IPCC, 2007; Levina and Tirpak, 2006: 25).

Unless otherwise specified, any reference to climate change in this study should be seen to include the increase in climate variability.

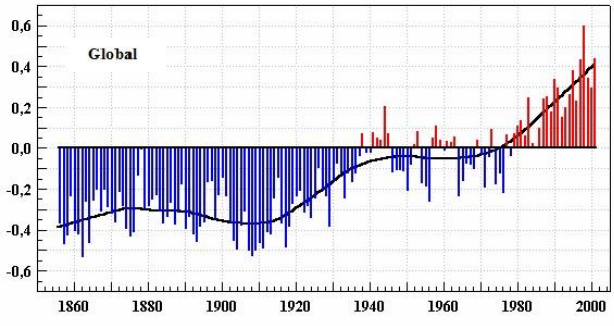


Fig. 1: Annual Global mean temperature increase.
Source: Gruza and Rankova, 2004

It is important to note the distinction between seasonal CC – patterns of changes in climate occurring cyclically usually over a yearly period – and long-term CC – which refers to the variation in the Earth's global climate or regional climates over longer periods of time (Heuze, 2007; Young, 2012). The predictability and stability of the cycles of seasonal CC, i.e. seasons and related aspects, allowed the creation and development of the complex bodies of knowledge that underpin the many activities in which rural and indigenous peoples, small-scale farmers in particular, engage with their key livelihood resources for their survival and wellbeing (Kirkland, 2012: 4).

Recent global warming, characterized by a rise in the surface air (or water in the case of oceans) temperature as averaged over the globe, each hemisphere, or most large continental or oceanic regions, has a strong impact on climate interactions. This rise in the average temperature of the Earth's atmosphere is seen as an unprecedented event in the last 1000 years and has seen the annual mean global surface air temperature increased by 0.6 ± 0.2ºC over the past century. Three distinct intervals can be identified: warming over 1910-1945, weak cooling from 1946-1975, and the most intense warming starting in 1976 (see Fig. 1 and 2) (Gruza and Rankova, 2004: 3-4). This recent accelerated global warming is a strong factor

in the recent acceleration of broader changes in the Earth's climate system, i.e. climate change (Hilderman, 2011).

Although there is still some debate on the issue, most scientists seem to agree that recent global CC is linked to an increase in the concentration of greenhouse gases (GHG) such as carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3), as well as a range of human-made halocarbon GHGs that are present in small but potent amounts in the Earth's atmosphere, which contribute significantly to current CC (Vieira and Bazzo, 2007: 5-7; Garnaut, 2008: 29-30). Despite the impact of other GHG on the acceleration of global CC, most scientists and academics seem to agree on the concentration of CO_2 as the most appropriate indicator for the concentration of GHG in our atmosphere (Garnaut, 2008: 27-30).

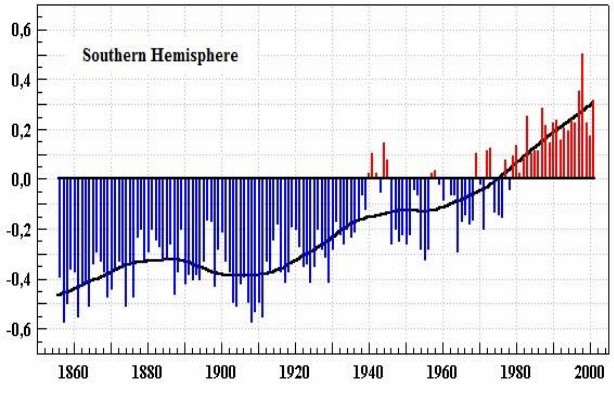


Fig. 2: Annual Southern Hemisphere mean temperature increase. **Source:** Gruza and Rankova, 2004

In South Africa, the vast majority of CO_2 emissions are produced by the electricity sector (78.9%), followed by industrial processes and process use (14.9%) and agriculture (4.9%). The main reason for this carbon-intensiveness is the heavy reliance of South Africa's electricity sector on low-cost fossil fuels-based electricity generation as well as the intensive use of oil-based products in agriculture (National Treasury. Republic of South Africa, 2010).

3.3. Expected impacts of CC in Southern Africa

Some of the expected impacts of CC in Southern Africa include, but are not restricted to decreased rainfall, increased temperature and evaporation in dry areas; frequent drought spells leading to severe water shortage and increased risk of crop failure; change in planting dates of annual crops; increased fungal outbreaks and insect infestations due to changes in temperature and humidity; decrease in forest area and area under cultivation; decline in crop and livestock production; increased risk of food shortage; reduction in ecosystem integrity and resilience, and decline in biodiversity; and, sea level rise (Twomlow, Mugabe, Mwalec, Delved, Nanjae, Carberryf, Howdenf, 2008: 13; David, 2009: 9).

These changes will have a significant effect on the livelihoods of small-scale farmers (and their support agents) in Southern Africa. This arises from the fact that agricultural production remains the main source of livelihood for rural communities in Sub-Saharan Africa, providing employment to more than 60% of the population and contributing to about 30% of the gross domestic product (Nhemachena and Hassan, 2008). Small-scale farmers, whose livelihoods are even more dependent on the agro-ecosystems from which they derive their agricultural production (among others), stand to be especially vulnerable to devastating effects of CC (Twomlow *et al.*, 2008: 2). The vulnerability of their livelihoods to CC is ultimately determined by the interaction between the adaptive capacity of small-scale farmers, and the exposure and sensitivity of their livelihoods to CC (this relationship will be covered in more detail in section 4.2 in chapter 2) (Riché *et al*., 2009).

3.4. Climate Change in South Africa

Climate change is expected to make South African temperatures climb, reduce the rains and change their timing (Benhin, 2006). Such shifts will completely change life as we know it, meaning that parts of the country will be much drier, and increased evaporation will ensure an overall decrease in water availability (South Africa, 2011). South Africa's average rainfall, estimated at 450mm per year, is well below the world's average of 860mm, while evaporation is comparatively high. In addition, surface and underground water resources are limited (Benhin, 2006). Statistical evidence suggests that South Africa has been getting hotter over the past four decades, with average yearly temperatures increasing by 0.13°C per decade between 1960 and 2003. There has also been an increase in the number of warmer days and a decrease in the number of cooler ones, which imply changes in natural and agro-ecosystems which can have a negative impact on the livelihoods of rural populations (*ibid*).

Because of its close link to many CC-related concerns, including biodiversity loss, global warming and water availability, agriculture, at small-scale in particular, stands to be greatly affected by CC (Schulz, 2008). Research predicts that a simultaneous decrease in rainfall and increase in temperature will have a strong adverse effect on South African subsistence farmers, predicting a 151% loss in net revenue by 2080 (Financial and Fiscal Commission, 2012: 66; Gbetibouo and Ringler, 2009). This view is in line with that of studies based on predictions regarding the physiological responses of affected plants, which go further saying that such changes will induce (or require) major shifts in farming practices and knowledge, such as shifting of planting times, changes in planting techniques, changes in the choice of crops, to name but a few, in the different regions of the country (Gbetibouo and Ringler, 2009; Altieri and Koohafkan, 2008).

3.5. Climate Change in the Western Cape

The Western Cape has a Mediterranean climate, receiving the bulk of its rainfall (80%) in the winter months, and experiences relatively dry summers (Tyson and Preston-Whyte, 2000; Marincowitz and Barnard, 2002). The average precipitation of the province is in the region of 300mm/a, and although the annual rainfall for some areas is more than 2 000 mm, the arid areas in the Karoo and the North Western Cape have a rainfall of less than 150 mm per annum (Midgley, Chapman, Hewitson, Johnston, de Wit, Ziervogel, Mukheibir,, van Niekerk, Tadross, van Wilgen, Kgope, Morant, Theron, Scholes, Forsyth, 2005; Marincowitz and Barnard, 2002). Changes in atmospheric circulation patterns over the last 40 years have impacted on rainfall spatial patterns as well as the frequency of hot/dry-spells throughout the Cape province. Changes in precipitation in mountainous and lowland areas have also been observed (Midgley *et al.*, 2005). CC projections for the Western Cape predict a drying trend from west to east with a weakening of winter rainfall; possibly slightly more summer rainfall (mainly in the east of the province); a shift to more irregular rainfall of possibly greater intensity, and rising mean, minimum and maximum temperatures (*ibid*). Given the already low average precipitation of the province, such changes in climate are having and will continue to have a strong impact on the farming systems and local conditions on which small-scale farmers in the province rely for their livelihoods (*ibid*).

3.6. Climate conditions and CC projections for the Ebenhaeser community

The Ebenhaeser community is situated in the lowlands of the West Coast district of the Western Cape, about 15km from the sea. The average annual rainfall for the district is 115mm/a, way below the provincial average (Illgner, 2008). As shown in Fig. 3, just like the rest of the province it receives the bulk of its rain in the winter months (wide bars), with a high level of variability of monthly rainfall quantities on a year to year basis (thin bars). Climate data and CC projections are available, and are based on data of he last 30 years, originating from the Vredendal Weather Station (Climate System Analysis Group (CSAG), 2012).

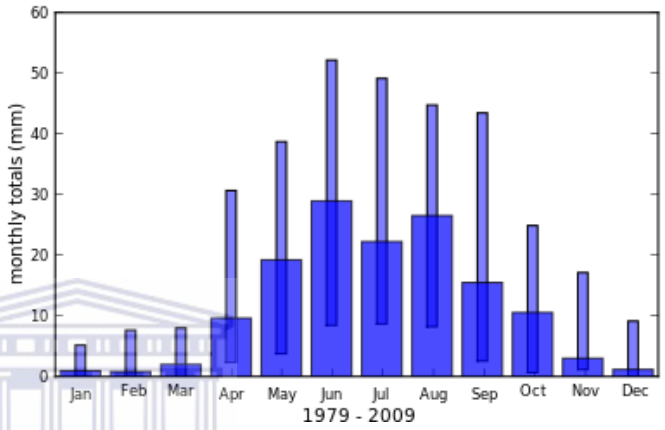


Fig. 3.: Total Rainfall and annual monthly variability. **Source**: CSAG, 2012

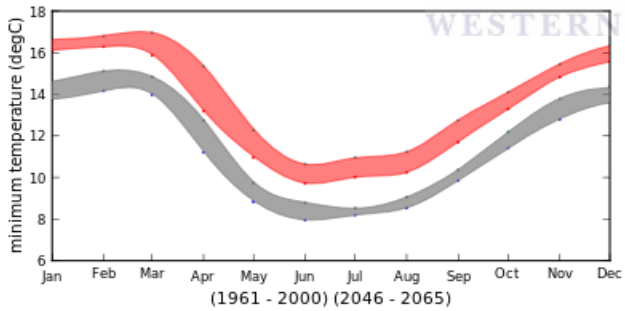


Fig. 4: Current vs. future minimum temperature. **Source:** CSAG, 2012

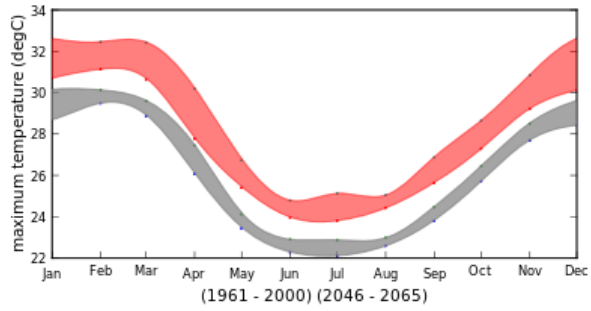


Fig. 5: Current vs. future maximum temperature. **Source:** CSAG, 2012

CC projections for the area were arrived at using statistical downscaling methods of Global Climate Models (GCMs). It is important to note that although the data could be used as indicators of CC, the course of spatial resolution of the GCMs mean shows that they are an inadequate basis for assessing details of the effects of CC on land-surface processes at regional level (CSAG, 2012). As such, this information about

the effects of CC on land-surface processes will be complemented by findings arising from the data collection stage of this study.

As mentioned previously, the main indicators of CC are temperature and precipitation. Fig. 4 and Fig. 5 show the current (grey envelope) versus future (red envelope) minimum and maximum temperature ranges for the region, respectively. These projections predict a significant increase (in the order of 1ºC to 2ºC) in both minimum and maximum daily temperatures. In terms precipitation, Fig. 6 shows the current (grey bar) versus projected (red bar) rain totals for the region. These projections (1961 – 2000) predicted a significant change

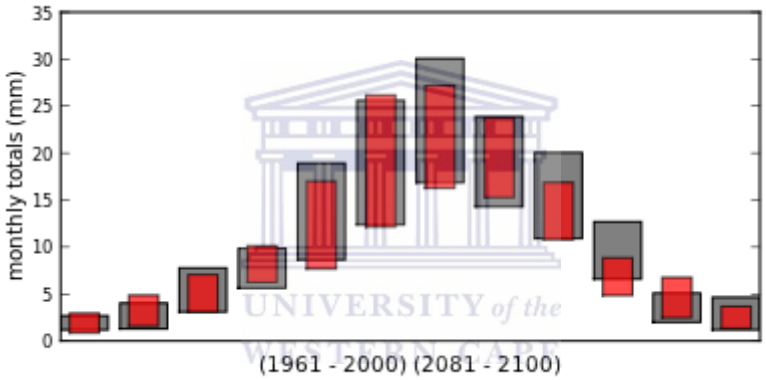


Fig. 6: Current vs. future rainfall totals. **Source:** CSAG, 2012

in total monthly rainfall, with a significant reduction in some months.

Another fact that came to light during the preliminary meeting with farmers was that although local small-scale farmers had been making efforts to adapt their farming practices to cope with such changes, it seemed that to a great extent they had been left to their own devices in this process, i.e., no support had been forthcoming to farmers, either from government or NGO's operating in the community focusing on or with embedded CC components. Herein lies the assumption that they rely on their local knowledge to develop (perceived) suitable coping practices to cope with the adverse effects of CC. Reaching a better understanding of the dynamics of this process was the main goal of this research.

4. SMALL-SCALE FARMING

For the purpose of clarification, although several definitions of small-scale farming are available, the working definition of **small-scale farming** for this study is as follows:

> ***"Small-scale farmers** are famers using hoes and other simple equipment to cultivate small portions of land (not more then 2-3 hectares), using mainly family labour and occasional part-time hired labour, producing a significant proportion of the basic consumption needs of the local community, while purchasing some consumption goods and some agricultural inputs, and selling some of the products outside the community"* (Barker, 1989: 380; Cousins, 2009, Kirsten, 1998a).

From this definition one can easily infer the importance of farming as a source of livelihood for small-farmers. Small-scale farming entails the development, accumulation and use of various farming practices and local knowledge bodies (agricultural and environmental.) which are derived from, and applied to, the local agro-ecosystem for agricultural production, on which their livelihoods depend (Altieri and Koohafkan, 2008). As explained by Taylor (2009: 2) climate is a major production factor in farming and is a major cause of uncertainty in agriculture, manifesting itself in crop yields, pests, or crop failures, and influencing the type of crop or livestock that can be grown in a given area. Based on these data one can infer the parallel that exists between CC and its effects on the local agro-ecosystems as well as its effects on the livelihoods of these farmers.

The acceleration of environmental degradation and CC have direct effects on agricultural productivity and food security, having an impact on the various biological processes at organism or farm level, as well as environmental and physical processes at production and landscape (Nelson, 2010: 2). As such, it will continue to have an impact on key processes in the agro-ecosystem such as affecting soil processes and properties, soil degradation

(including soil erosion, acidification, salinization and loss of fertility,), altering the cycles and in some cases providing more conducive conditions for the proliferation of plant pests and diseases, conversely affecting local bodies of knowledge and farming practices (Altieri and Koohafkan, 2008; Várallyay, 2007: 4-7). In addition, Altieri and Kohafkan (2008) state that the possible increase in pest and disease infestations linked to CC may bring about greater use of chemical pesticides to control them, which may in itself enhance production costs and also increase environmental problems associated with agrochemical use.

Notwithstanding the above, a wide variety of factors determine the degree to which climatic events affect an agricultural system. These include, but are not restricted to the types of crops or livestock produced, the scale of the operation, the farm's orientation towards commercial or subsistence purposes, the quality of the natural resources and specific human variables of the farm's managers (e.g., education, risk tolerance and age,.). Other external factors such as institutional factors, including the rules, norms and policies that govern land tenure, the availability of markets, financial capital, insurance and support programs, and the degree of technology development and distribution also mediate this process (Marincowitz and Barnard, 2002).

4.1. Small-scale farming in South Africa

In South Africa, small-scale farming has been historically equated with a backward, non-productive, non-commercial, type of subsistence agriculture. However, various studies show that this is not necessarily the case (Kirsten and van Zyl, 1998b). According to the South African Department of Agriculture (DoA, 2001), there are approximately 240 000 black farmers in South Africa who provide a livelihood for more than a million of their family members, and provide temporary employment for another 500 000 people. The source further

estimates that there are approximately three million small-scale farmers who produce food primarily to meet household consumption needs (*ibid*).

In contrast to the situation in many other countries in the world where one would find a whole range of farm sizes, ranging from the very small or subsistence farms to the very large farmer/agribusinesses, South African agriculture is comprised of only two main categories of farmers: subsistence farmers, mainly in the former homeland (including coloured reserves) areas; and the large-scale commercial (mainly white) farmers (Kirsten and van Zyl, 1998a; Alliber and Hart, 2009). This is evidenced by statistics showing that by 1998, while there were approximately 40000 commercial farm units in the country using 87% of the total agricultural land to produce about 95% of South Africa's agricultural output (Stats SA, 2009), approximately 2.1 million small-scale and emerging farmers in South Africa were settled and produced on the remaining 13% of the South African agricultural land (Feynes & Meyer, 2003). Although the actual numbers of these farmers are far from clear (Alliber and Hart, 2009), most of these subsistence and smallholder producers are still predominantly settled in the former homelands and rural reserves (Feynes & Meyer, 2003).The target group for this research is an example of the latter.

4.2. Small-scale farmers' vulnerability to CC

CC is putting significant strain on some of basic resources which form the basis of rural livelihoods (Kirsten and van Zyl, 1998b). As such, CC can be seen in this context as an important additional stressor on the already vulnerable livelihoods of small-scale farmers of the Western Cape (Senbeta, 2009; Abeka, *et al.,* 2012). It becomes important to understand small-scale farmers' vulnerability to CC in the context of this study, as it is an important factor with regard to their ability and the extent to which they respond to unprecedented changes in climate.

Kelly and Adger (2000) point out that many definitions of vulnerability have been put forward by scholars from various backgrounds. These definitions are derived from a wide range of backgrounds such as natural hazards, food insecurity and even climate studies, and engage the concept from different perspectives. The authors explain that the concept of vulnerability can be seen as an *end point*, a *focal point*, or a *starting point* (*ibid*). It is the view of the researcher that the latter explanation is most in line with the nature of this study, as understanding the vulnerability of small-scale farmers' livelihoods to CC is an important step in achieving this study's goal of understanding their process of developing CC coping practices. O'Brien, Eriksen, Schjolden and Nygaard (2004) concur, stating that this interpretation can be used to identify adaptive capacity, helping to illuminate adaptation options and constraints.

Regardless of the perspective, academic literature is consistent in pointing to the notion that the vulnerability of any system (at any scale) is reflective of (or a function of) the exposure and sensitivity of that system to hazardous conditions and the ability, capacity or resilience of the system to cope, adapt or recover from the effects of those conditions (Smit and Wandel, 2006). As such, CC coping practices of small-scale farmers not only respond to the direct impacts of CC on their livelihoods, but are also conceived and applied within a wide variety of economic (e.g.: poverty, market access) social (e.g.: local knowledge, community cohesion) political (e.g.: government support for small-farmers) and environmental (e.g.: local natural environment, local climate) circumstances (O'Brien *et al*., 2004). The basic vulnerability relationships can be conceptualised as portrayed in the Venn diagram presented below (Fig.7) as a means of visualising the ways in which the vulnerability of a community is shaped (Smit and Wandel, 2006).

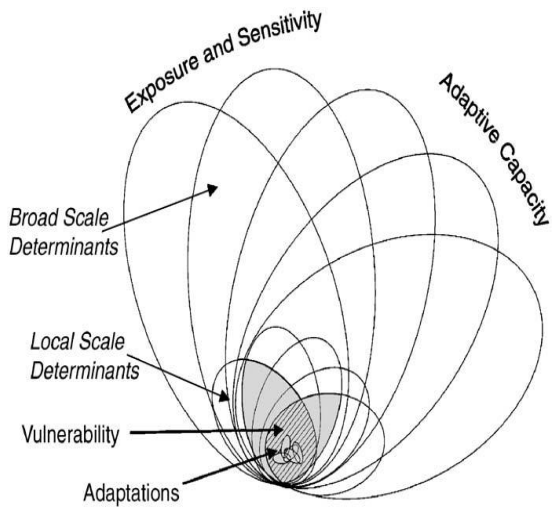


Fig. 7: Nested hierarchy of vulnerability. *Source*: Smit and Wandel, 2006

Here, the larger sets represent the broader stresses and forces that determine exposure and sensitivity and shape adaptive capacity at the local or community level, denoted by the smaller embedded sets. The interaction of environmental and social forces determines exposures and sensitivities, and various social, cultural, political and economic forces shape adaptive capacity (*ibid*). The overlap recognizes that the processes driving exposure, sensitivity and adaptive capacity are frequently interdependent (*ibid*). The finer scale interaction of these elements represents local vulnerability, and adaptations are particular expressions of the inherent adaptive capacity (*ibid*).

Also important is the fact that vulnerability to CC is highly context-specific, meaning that its elements of exposure, sensitivity and adaptive capacity, and their determinants are dynamic, and vary by type, from stimulus to stimulus, and they are time-, place- and system-specific.

The vulnerability of small-scale farmers' livelihoods to CC is seen within the context of this study as being determined by their exposure and sensitivity to CC, along with their adaptive capacity. Here, a series of **underlying drivers of vulnerability**, including a variety of economic, social, political and environmental circumstances prevalent in their local communities, as well as the wealth and adaptability of bodies of local knowledge, influence not only the impact of CC on the key livelihood resources of farmers, but also the availability, effectiveness and sustainability of locally developed CC-related coping practices. Ultimately, the interplay between the impact of CC on these key livelihood resources and the existing CC coping practices determines the vulnerability of small-scale farmers to CC

(Kilian, Gibson, Henderson, King, Pretorius, Koch, 2006; Midgley *et al.*, 2005: 96-98; Müller, 2009: 1 Gbetibouo and Ringler, 2009).

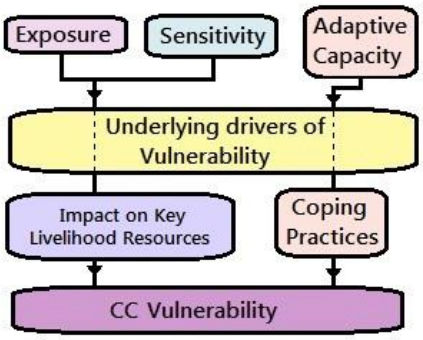


Fig. 8: Vulnerability framework, adapted from Gbetibouo and Ringler, 2009

Although CC aggravates already existing problems faced by men and women in developing countries whose livelihoods depend on agriculture and access to natural and other key livelihood resources, its impact will not be felt equally across gender lines (Abeka *et al.*, 2012: 8; Nelson, 2010). This imbalance is directly, though not exclusively, related to gender-differentiated ways in which communities interact with their physical environment and with the differing responsibilities of men and women as they carry out their responsibilities on the farm and in the household (Nelson, 2010: vii). Additionally, women's social roles, discrimination and poverty mean that they are often disproportionately impacted by the negative effects of CC (Govender, 2012 Nelson, 2010).

In sum, this means that in the context of CC, men and women contribute differently to the causes of CC, are differently affected by CC, react differently to its impacts, and given the choice, favour different solutions for dealing with the consequences of CC (Röhr, 2009). For example, in dealing with the impacts of CC, women tend to be more sensitive to risks and are more willing to change lifestyles, while men believe more strongly in technical solutions (*ibid*).

4.2.1. CC exposure and sensitivity of small-scale farmers

Exposure and sensitivity are almost inseparable properties of a community and are, in the context of CC, dependent on the interaction between the characteristics of the community, such as local infrastructure, community cohesion and cooperation, gender relations, among others, and on the attributes of the climate stimulus, which in this case refer to the various

common features of CC, such as shifts in seasons, changes in rain patterns, increase in average temperature and increased unpredictability of climate,. (Smit and Wandel, 2006; Twomlow *et al.*, 2008: 3-4; David, 2009: 9-10).

CC exposure is determined by the magnitude, character and rate of climate change in a certain geographic area (Riché *et al.*, 2009). Unfortunately, the limited availability of long-term and/or continuous meteorological records, as well as the lack of scientific projections at more localized scales, in particular for the Ebenhaeser community, is often insufficient for analysing local exposure to climate change (*ibid*). To get around this limitation, the researcher used available meteorological and projection information coupled with information arising from the analysis of local-level climate observations captured through consultations with small-scale farmers and other local actors of the Ebenhaeser community.

O the other hand, small-scale farmer **sensitivity** to climate change is the degree to which they are adversely or beneficially affected by climate-related stimuli. It largely depends on the main livelihood activities (including its dependence on livestock and rain-fed agriculture), **key livelihood resources** (natural, physical, social, human, and financial), and the impacts of climate hazards on these key resources. Ultimately, sensitivity reflects the responsiveness of a system to climatic hazards, determining the degree to which a group will be affected by environmental stress (Stockholm Environment Institute, 2004). Their being highly dependent on agriculture – a sector considered to be highly sensitive to climate –, the livelihoods of small-scale farmers are especially sensitive to CC (Riché, *et al.*, 2009).

4.2.2. **Adaptive capacities of small-scale farmers**

The **adaptive capacity** of a community is its ability to adjust to CC, to moderate or cope with its impacts, and to take advantage of the opportunities that may arise with it (IPCC, 2007). It is context-specific and often determined by a range of factors, processes and structures, and is understood in terms of some basic socio-economic factors or determinants. These factors include the community's past and current strategies for coping with climate stress and whether these strategies are feasible in the face of future climate change; availability of possible strategies to prepare for and cope with future changes; as well as the different enabling conditions and barriers to adaptation (Riché *et al.*, 2009, IPCC, 2007, Smit and Wandel, 2006). Additionally, factors such as poverty and access to economic opportunities, the nature and degree of support (or discrimination) that communities receive from the state, the effectiveness of local knowledge and decision-making processes, and the extent of social cohesion within their own group and with surrounding vulnerable groups also determine the adaptive capacity of small-scale farmers (Omolo, 2011).

The role of community conflict as a hindrance to the adaptive efforts of small-scale farmers plays an important part in the adaptive capacity of small-scale farmers. Here, all the above mentioned factors, along with increased frequency and intensity of CC-related stresses, may increase competition for scarce resources such as land and water, potentially intensifying community conflicts, which ultimately reduce small-scale farmers' adaptive capacity (Stark, 2011; Omolo, 2011).

Generally, a community that is more exposed and sensitive to a climate stimulus, condition or hazard will be more vulnerable, whereas a system that has more adaptive capacity will tend to be less vulnerable (Smit and Wandel, 2006). Within the case setting of this study, factors such as poverty, lack of infrastructure, limited resources, and internal conflict render the

adaptive capacity of local small-scale farmers in the face of CC correspondingly low (Riché *et al*., 2009).

Furthermore, given the traditional gender roles, women tend to be reliant on more climate sensitive activities and are also likely to have fewer resources to adapt to CC (Nelson, 2010: vii). As explained by Abeka *et al.* (2012: 8), women farmers' limited access to information and resources such as land and credit further prevents them from developing their capacities in agriculture although they play a crucial role in food security.

Nonetheless, and despite their vulnerability to long-term CC, small-scale farmers world-wide are traditionally able to cope with shorter term seasonal climate variability (Nakashima *et al.*, 2012). Small-scale farmers living in difficult environments have developed ways to adapt to the particular changes in circumstances of unpredictable environments, both short- and long-term, for centuries (Laube, Schraven and Awo, 2011; Twomlow, *et al.*, 2008). Laube *et al.* (2011), go on to state that they commonly rely on risk-mitigating patterns of production, diversification of agricultural production (subsistence and market production), alternative sources of livelihood, and different coping strategies in the case of disasters to cope with "routine" climate variability. These coping practices are naturally based on the local knowledge of the affected communities (Kirkland, 2012: 3-4). According to Twomlow *et al.* (2008: 13), some of the adaptation measures most commonly cited in literature to combat climate variability include actions such as increasing area irrigation to boost crop production; introduction of low water-use crops and adoption of sustainable water resource management (such as seasonal rainfall harvest and water quality control); reduction of water loss through water conserving technologies; adjusting farming areas and reducing animal population. As explained previously, these adaptation measures are seen here as manifestations of the adaptive capacity of small-scale farmers and, to avoid confusion, are referred to as coping practices within the context of this study.

4.3. Climate Change Coping Practices of Small-scale Farmers

Recent research shows that small-scale farmers around the world have been applying their local knowledge to develop measures to deal with current challenges brought upon them by CC (David, 2009; Riché *et al*., 2009; Abeka, *et al.*, 2012). Family farmers in the Peruvian Andes, for example, cope with climate change as well as other social, cultural and environmental changes by taking advantage of indigenous knowledge bodies (e.g. environmental, agricultural) inherited from ancient Peruvian culture, and applying it to their local farming systems (Kirkland, 2012).

Similarly, a study conducted in the Kereita forest (Kenya), David (2009), found that the communities were employing a number of local knowledge-based strategies to cope with climate change, including diversification of crops; improvement of local farming methods; increased use of fast growing crops; water harvesting and irrigation (David, 2009: 37). As with other studies around the world, he found that besides changes in farming practices, CC coping practices include diversification on and beyond the farm and migration (David, 2009: 37; Abeka et al., 2012; Below et al., 2010). Perhaps not surprisingly, field research has been consistent in showing that the most common coping practices developed by African small-scale farmers are directly related to changes in farming practices and technology aimed at coping with current CC (Below et *al.*, 2010).

Many of these measures could be effective in responding to future CC. However, not all current local strategies to cope with hazards are efficient or appropriate for long term adaptation to CC (Riché *et al*., 2009). Riché *et al*. (2009), based on a study conducted in two Ethiopian rural communities, point out that some coping strategies can worsen environmental degradation and thereby diminish future adaptive capacity and livelihood options of small-scale farmers. Such coping practices are usually based on short-term considerations, survival

needs and lack of information or imperfect foresight, and their sustainability depends on factors such as the intensity, duration and frequency of hazards (*ibid*).

At title of example, is the case of the Borana and Somali rural communities in Ethiopia, where, according to Riché *et al*. (2009), the unsustainability of various traditional coping strategies in the face of current climate change is already visible. Here, traditional coping strategies such as charcoal and firewood selling, food rationing, and others might be efficient coping strategies when hazards (drought, in this case) are well distanced from each other (6-8 years). But if there is a major drought almost every year, charcoal and firewood selling leads to massive deforestation, making this strategy obsolete in the long run, and leading to intensification of climate change impacts; continuous food rationing leads to malnutrition, decreased disease resistance and human capabilities, and sometimes even death (*ibid*).

It is common to find misinterpretations and confusion in the use of terminology referring to community responses to CC. For the purpose of clarification, as opposed to adaptation practices which require an additional thinking ahead and planning of measures to improve the adaptive capacity (Abeka *et al.*, 2012), the term **coping practices** is used within the context of this study to refer to:

> "*the spontaneous or deliberate reactive adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities posed by CC"* (Levina and Tirpak, 2006; Morton, 2007).

The development of these coping practices is based on past experiences. These experiences, which are accumulated in the local knowledge systems, are passed on from one generation to another, and provide the foundation for small scale farmers' own ideas on how to survive during harsh times, taking place in order to manage the losses or take advantage of the opportunities presented by a changing climate (Magunda, Lutalo, and Nanyonga, 2010).

Taking record of these coping strategies becomes important within the context of this study, as by assessing current local coping strategies, as well as determining their effectiveness and sustainability, it will give the researcher a better insight into ways how these practices reflect the adaptive capacity of small-scale farmers in the Ebenhaeser community in relation to CC (Riché *et al*., 2009).

One of the great threats CC poses to small-scale farmers is that the changes associated with climate change may eventually make traditional knowledge and practices unworkable (Kirkland, 2012). As Kirkland (2012), explains, although indigenous communities have been interacting with their local environments for millennia, recent global warming represents a climactic shift larger than anything they've ever experienced. This means that as CC goes on, ecosystems will become increasingly different from those of past centuries, resulting in a tendency for communities to be in a position where their traditional knowledge becomes less and less accurate and relevant (*ibid*; Blaikie, 1992). This ultimately results in the potential reduction of the adaptive capacity of small-scale farmers, reducing coping options, and increasing their vulnerability to CC.

5. LOCAL KNOWLEDGE

Every society has a large body of technical knowledge based on careful observation and use of its natural resources (Warren, 1991). This local knowledge – also referred to in literature as indigenous or traditional knowledge – is an integral part of small scale farmers' lives. For simplicity purposes the terms Indigenous, Traditional and **Local knowledge (LK)** will be used interchangeably throughout this discussion, and are seen in the context of this study as: […] a dynamic and complex body of know-how, practices and skills that are developed and sustained by peoples/communities with shared histories and experiences (Beckford and

Barker, 2007), encompassing enormous knowledge about the community's surrounding natural environment, including weather patterns (Kirkland, 2009: 3).

At first glance, indigenous knowledge may appear very different from Western science (Kirkland, 2012). While in Western cultures knowledge (in particular, scientific knowledge) is presented in opposition to practice (science vs. technology) and the rational is presented in opposition to the spiritual (science vs. religion), in the indigenous context, these elements are combined in a holistic understanding of interaction with the surrounding environment (Nakashima *et al.*, 2012; Mazzocchi, 2006). As such, whereas Western science is objective and quantitative, traditional knowledge is mainly subjective and qualitative (Mazzocchi, 2006).

Nevertheless, as pointed out by Kirkland (2012), indigenous knowledge is also empirical and based on observation and experiment, meaning that practitioners of indigenous knowledge "*draw deductive inferences from first premises, deliberately and systematically verify these inferences in relation to experience, and models of the world are reflexively adjusted to conform to observed regularities in the course of events*" (Scott, 2011, cited in Kirkland, 2012: 4) . Indigenous knowledge thus encompasses and is determined by not only empirical understandings and deductive thought, but also by community know-how, practices and technology; social organization and institutions; and spirituality, rituals, rites and worldview (Nakashima and Roué, 2002).

Gunderson and Holling (2002) go further, arguing that traditional knowledge is by its very nature a cumulative, culturally transmitted body of knowledge that has evolved by adaptive processes. As such, although some of its elements may be centuries old, indigenous knowledge is dynamic, constantly growing and changing as people react to new conditions (Kirkland, 2012). Nevertheless, various factors influence the spread of the local knowledge,

and depend on the specific functions of individuals or groups within the community (Folke, 2006; Greiner, 1998).

5.1. Local knowledge and Gender

According to Fernandéz (1994), local knowledge bodies are structured by systems of classification, sets of empirical observations about local environments, and systems of self-management that govern resource use at community level. As such, they generate task-specific experiences, knowledge and skills, and mean local knowledge bodies are accessible, in the first place, to those members of a social group charged with specific resource management and production responsibilities. In this sense, indigenous knowledge systems are by their very nature gendered (Ogachi, 2011; Fernandéz, 1994). Fernández (1994) also adds that the degree of gender specificity attached to the local knowledge depends not only on the way responsibilities are allocated but also on the degree of flexibility men and women (particularly women) have to show to carry out the work. Hence, whilst such differences are clear, it should not be assumed that knowledge is exclusive and limited to areas within which people have a role to play (*ibid*).

The researcher understands the importance of this gender dimension of CC impact on small-scale farmers of the Ebenhaeser community, and recognizes that a full understanding of gender implications of the impact of CC on the small-scale farmers of the Ebenhaeser community requires dedicated, in-depth analysis. However, given the size and nature of this study, this in-depth analysis was not possible. Nonetheless, efforts were made to capture some of the gender dynamics in the responses of the community's small-scale farmers to CC.

5.2. Local Knowledge of Small-scale Farmers

As groups of natural resource users, small-scale farmers also create their own observations and understanding based on the accumulation of generations of observation and trial-and-error experience (Gunderson and Holling, 2002). This local knowledge and knowhow is passed down from generation to generation, often by word of mouth, and provides the basis for people's livelihoods, which are in turn at the centre of societal efforts to adapt to variability and change (Mazzocchi, 2006; Nakashima *et al.*, 2012; Abeka, *et al.*, 2012; Beckford and Barker, 2007; Warren, 1991). It is the basis for local-level decision-making on a host of activities in rural communities including agriculture, health care, food preparation, education, natural-resource management, as well as strategies for coping with environmental fluctuations and external forces of change (Warren, 1991).

As experienced and attentive observers that they are, small-scale farmers have accumulated sizable and sophisticated bodies of knowledge and practices about their environment, its variability and transformation, as well as the practices, techniques, and technologies used by them to ensure their livelihoods (Kirkland, 2012). Among others, their local knowledge – in the form of weather prediction strategies, crop varieties, agricultural practices, water storage methods, building techniques, and more – provide tools for managing climactic change, helping small-scale farmers maintain their quality of life (*ibid*).

Nevertheless, various factors influence the erosion of this local knowledge. Apart from the aforementioned effects of the current rapid rate of CC on the relevancy of local knowledge, and the natural erosion of local knowledge as techniques and tools fall out of use, pressures of modernisation and cultural homogenisation have been influencing an increased rate of indigenous knowledge erosion (Grenier, 1998).

The ready availability of many commercial foods makes some biodiversity *seem* less relevant, such as seed and crop varieties selected over years for their long-term storage

attributes (Greiner, 1998; Wooten, 2003). Additionally, many of the traditional networks which farmers developed to traditionally maintain their indigenous crop varieties by keeping household seed stocks and by obtaining seed through traditional family and community networks as well as exchanges with nearby communities have been disrupted or no longer exist (*ibid*).

Furthermore, despite the high costs and failure of green-revolution technology suggesting its poor long-term feasibility, in the short-term chemical inputs *seem* to reduce the need to tailor varieties to specific local conditions, contributing to the demise of local varieties (Grenier, 1998). Nevertheless, in countries like South Africa, where this technology forms the basis of agricultural support and extension to small-scale farmers (often the only support these farmers receive), this practice has the very real potential of wiping out a significant portion of local small-scale farmers' farming knowledge, greatly hindering their adaptive capacity. As explained by Shebby (2010: 12),

> […] once a farmer does acquire the tools necessary to compete in the post-Green Revolution market, he or she is then trapped in a cycle that is nearly impossible to break, as modern varieties of seeds that were developed for this new technology require heavy irrigation and applications of chemicals to be successful. Once a farmer applies these chemicals to the soil, the soil degrades and is left depleted of essential nutrients. To make up for that loss, the farmer needs to use even more fertilizers to make up for what is lacking. Additionally, the use of pesticides leads to the creation of pesticide-resistant pests. This vicious cycle leads to the need for more chemicals to keep up with the changing chemistry of pests and pesticides.

Other factors such as the lack of education and work opportunities in the community and lack of youth interest or opportunity to learn traditional methods mean that neither children nor adults spend much time in the community. This causes a divide between generations,

disrupting the traditional channels of communication, and making it harder for the older generation to transmit their knowledge to the younger ones (Greiner, 1998; Wooten, 2003).

Finally, the fact that indigenous knowledge bodies are mostly transmitted orally, which means it is vulnerable to rapid change – such as when people are displaced or when young people acquire values and lifestyles that are different to those of their elders (Greiner, 1998; Wooten, 2003).

As we will see in the data presentation and analysis sections of this study, these examples are particularly relevant for our discussion. Many of them are manifested in our target community, and are tied up to its history of past oppression, as well as to the effects of current development policies of the South African government, particularly with regards to agricultural development.

6. CONCEPTUAL/THEORETICAL FRAMEWORK

As explained in the previous section, projections of CC around the world point to the strong impacts it will have in rural areas, especially on already water-strapped areas such as those in the Western Cape. The livelihoods of small-scale farmers such as those from the Ebenhaeser community – the target group for this study – are especially vulnerable to CC, as they are directly linked to agriculture and rely directly on climate-sensitive natural resources.

The vulnerability of small-scale farmers in relation to CC and its wide-ranging effects is contained within the framework of (a) their exposure (magnitude, character and rate of climate change); (b) their sensitivity (the degree to which they are adversely or beneficially affected by climate-related stimuli) to hazardous conditions; and, (c) their ability, capacity or resilience to cope with, adapt to or recover from the effects of those conditions (adaptive capacity) (see Fig. 4) (Kilian, *et al.*, 2006; Midgley *et al.*, 2005: 96-98; Müller, 2009: 1;

Gbetibouo and Ringler, 2009). Additionally, various social, cultural, political and economic forces shape these small-scale farmers' adaptive capacity (Smit and Wandel, 2006), which is materialized in the form of the coping practices which they developed based on the various bodies of local knowledge, and utilized in response to the external threat of CC (Gbetibouo and Ringler, 2009).

Table 1: **Climate Change Vulnerability Framework**

Exposure	Sensitivity	Adaptive Capacity
Which climate-related hazards affect livelihoods? What have been the observed changes in the timing, frequency, and intensity of these hazards? How do these climate-related hazards interact with non-climate hazards? What are the projected impacts of future climate change in the research areas? How do community observations compare?	How sensitive are livelihood activities to climate change? Indicators of sensitivity include: - Impact of CC on key livelihood resources (natural, human, social, physical and financial) - Dependence on rain-fed agriculture - Crop mix/types (are they resilient species?) - Environmental conditions (type, level, rate of degradation)	What are some of the socio -economic factors determining adaptive capacity? - Activities currently undertaken to cope with climate hazards? - Effectiveness and sustainability of coping practices What are some options for risk management and coping with future changes? - Activities to prepare for climate change impacts - Resources that are key to these activities What are the enabling conditions and barriers to adapting?

Table 1: Climate Change Vulnerability Framework (adapted from Riché *et al*., 2009)

Riché *et al.* (2009) present a framework for the analysis of CC vulnerability (see Table 1) as a tool for analysing the CC-related vulnerabilities of the livelihoods of rural communities. Apart from establishing the interrelation between the three components of small-scale farmer vulnerability to CC, this framework serves as a very useful lens through which the researcher is able to probe and understand the impact of CC on the livelihoods of the small-scale

farmers of the Ebenhaeser community as well as their adaptive capacity The framework provides a stepping stone towards reaching an overall understanding of how these components play out in the process of development of CC agriculture-related coping practices based on the local knowledge of the small-scale farmers.

Riché *et al*'s (2009) framework, as well as literature reviewed by the researcher positively indicates the impact of CC on the livelihoods of small-scale farmers (vulnerability). Furthermore, these sources seem to indicate that this impact is mediated by the interplay between the existing relationships of mutual-determination between the key livelihood resources available to local small-scale farmers and CC, their local knowledge and CC agriculture-based coping strategies; and the local underlying drivers of vulnerability.

It is a well-known fact that local knowledge mediates the daily living of small-scale farmers and provides tools for managing climatic change, underpinning many important farming decisions, and helping them maintain their quality of life (Kirkland, 2012; David, 2009; Valdivia, Gilles, Jetté, Quiroz, Espejo, 2003). Besides facilitating small-scale farmers' adaptation to the normal seasonal changes in climate, this local knowledge is also used to respond to the more recent changes in weather brought about by long-term CC (Kirkland, 2012). Nevertheless, the unprecedented changes and variability linked to recent CC have negative effects on bodies of local knowledge. By rendering some of this local knowledge obsolete, inapplicable, or unreliable, CC often prompts changes in farming practices (coping practices) which then update the various bodies of local

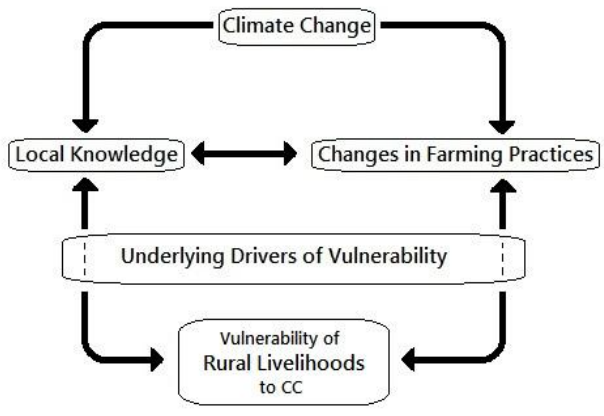


Fig. 9: **Conceptual framework** - Dynamic process of development of local knowledge-based CC coping practices by small-scale farmers (**Source:** Author)

knowledge on which small-scale farmers depend.

Finally, while the farmers' wealth of local knowledge and coping practices are partially dependent on the range of key livelihood resources available to local small-scale farmers, their success in reducing the impact of CC on the rural livelihoods of the small-scale farmers of the Ebenhaeser community is invariably influenced by the local underlying drivers of vulnerability. These notions form the basis of the theoretical/conceptual framework (see Fig. 6) developed by the researcher to guide the collection and analysis of data, as well as the findings of this study.

It is thus within this framework that the Ebenhaeser small-scale farmers' response to CC may be gauged in the mutual dynamic of how local knowledge and CC coping practices interact in mitigating against increasing local social vulnerabilities.

7. CHAPTER SUMMARY

This chapter was developed in an attempt to cover the available literature that is most relevant to the topic of this study, and that would set the background for the analysis, understanding, and interpretation of collected data.

To start with, the researcher covered key concepts related to Climate Change and variability. Additionally, the operational definition of the concept of CC was put forward, and some of the main impacts of CC in South Africa and in the Western Cape in particular were explained. The researcher went on to describe some of the main characteristics of small-scale farmers as well as the current situation with regard to small-scale farming in South Africa. Some of the main impacts of CC on small-scale farming and related vulnerabilities were spelled out and an operational definition of small-scale farming was provided.

Following this, the researcher went on to describe the adaptive capacity of small-scale farmers and how it manifests itself in the form of the coping practices used by small-scale farmers to deal with CC. An operational definition of these coping practices was given.

These coping practices are closely linked to the existing local knowledge of a community. This relationship, along with other important aspects of local knowledge were covered in this part of the discussion. Once again, an operational definition of local knowledge was presented.

In the final section of this chapter, the theorethical/Conceptual Framework section, the elements of CC, small-scale farmer vulnerability to CC, local knowledge of small-scale farmers and their agriculture-related coping practices were drawn together in a framework developed by the researcher to guide the analysis of the problematic of this study. The following chapter will describe the design and methodology used in this study.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

1. INTRODUCTION

A research design is "the blueprint of how you intend to conduct the research" (Babbie and Mouton, 2001: 74.), which as such is the overall plan for answering the research questions set, specifying the research methods, activities and techniques used in order to answer the aforementioned questions in a satisfactory manner (Scott and Garner, 2013).

In this research design and methodology chapter the researcher outlines the chosen methodology for the study, and the methods used for data collection, and for data presentation and analysis. Here, the researcher sets out the empirical setting of the small-scale farmers of the Ebenhaeser community, which serves as the context of this research project. Lastly, the chapter closes with a discussion on the important issues of the validity of the findings and conclusions arising from this study, and how this research was conducted.

2. RESEARCH METHODOLOGY

In order to illustrate the dynamics of the process of development of local knowledge-based coping practices of smallscale farmers of the Ebenhaeser community aimed at reducing the vulnerability of their livelihoods to CC, the researcher opted to use a qualitative methodology, as well as data collection and analysis methods in this study, which according to Miles and Huberman (1994) aims at producing coherent and illuminating descriptions and perspectives that are based on and consistent with a detailed study of the situation.

More specifically, this research methodology is inspired on the case study research format, which according to Yin (2009:59) is an empirical inquiry that "investigates a contemporary phenomenon within its real-life context and addresses a situation in which the boundaries between phenomenon and context are not clearly evident". Meyer (2001: 330-331) adds that case study formats allow for the use of theory or conceptual categories to guide the research and analysis of data. In further detail, this study is exploratory in nature, which, according to Zainal (2007: 1-2), is used to explore and investigate a contemporary real-life phenomenon through detailed contextual analysis of a limited number of events or conditions, and their relationships, enabling the researcher to closely examine the data within a specific context. The nature and size of this study implied that there would be no other cases available for replication, mandating the use of a single-case design. Ultimately, according to the typology of case studies put forward by Thomas (2011: 511-512), this is an illustrative case study, devised by the researcher to illustrate how local knowledge and agriculture-based coping practices of small-scale farmers of the Ebenhaeser community are adapted to deal with and attempt to reduce the vulnerability of their livelihoods to CC.

This study made use of in-depth individual, as well as semi-structured interviews and special focus groups with an aim to capture a deeper understanding of the physical and historical context in which the Ebenhaeser community is inserted. These interviews also provided a deeper insight on the impacts of climate change on local farming and how farmers adapted to the changing conditions and added pressures in CC. Transport and other data collection logistics of the study were made possible with the assistance of both the Surplus People's Project and EPIOS, a local community-based organisation working as an information hub as well as heading various development projects within the community.

3. RESEARCH SETTING - THE SMALL-SCALE FARMERS OF THE EBENHAESER COMMUNITY

Although the history of South African land dispossession can be traced back to the arrival of the first white settlers in the Cape, it was towards the end of the 1800's that the regime starting making heavy use of legislation as a main vehicle for dispossession, culminating in the formalization of the *apartheid* regime, and its oppressive model of segregated development (Weideman, 2004). One of the first main pieces of legislation in this direction was implemented in 1913, soon after the creation of the Union of South Africa in 1910 and the coming to power of the South African Party. This act – the Natives Land Act 27 of 1913 – prohibited land purchases by Africans outside of the scheduled reserves, making these the only places where Africans could legally occupy land. The 1913 Land Act also outlawed sharecropping and "squatting", effectively dispossessing millions of South Africans and immediately reduced African access to land by excluding over one-and-a-half million hectares of white owned land rented by Africans, as well as half a million hectares owned and occupied by Africans at the time (Klug, 1996).

The introduction of this system of "native reserves" was also common to other territories in colonial Africa (Basset, 1993). Coupled with this new policy were the "betterment planning" schemes implemented by the *apartheid* regime, and also common in other colonial states. These schemes involved measures such as dividing a given area (usually a rural ward or administrative area) into residential, arable and grazing land; relocating people from their dispersed homestead sites to sites in new, village-type residential areas; and demarcating and fencing arable lands and establishing fenced grazing camps (McAllister, 2010). Initially these schemes were motivated by a concern for the conservation of natural resources and lack of rural development. Later however, they came to be used to ensure a steady supply of cheap

migrant labour to the "white" South Africa, and then, due to economic and political developments, as a means of controlling the rural population (*ibid*; Basset, 1993).

In 1936, the Development Trust and Land Act allocated already promised land to the reserves, and created a trust with the purpose of acquiring and administering these areas(Thwala, 2006; Weideman, 1993). At a further stage, the Coloured Rural Areas Act 9 of 1987, stipulated that control of land in such "Rural Areas" should be vested in the Minister of Land Affairs, who would hold the land in trust for the benefit of the residents (Anderson, Jacobs, Janneck, Mayson and Piennaar 2000). Such areas were commonly known as Act 9 areas.

South Africa's history of colonialism, racism, *apartheid*, sexism, repressive practices as well as aspects such as economic deregulation, urbanization, natural resource endowments and environmental changes has led to a situation where the South African rural environment of today is diverse and largely dualistic in nature (Van Rooyen, Nqganweni, Groenwald and Fenyes, 1998; Kirsten, Van Zyl and Vink, 1998). As explained by Hall (2004), South Africa's agrarian structure is 'dualistic' in the sense that it comprises, in the former 'white' rural areas, a capital-intensive commercial farming sector engaged in large-scale production strongly linked to global markets and, in the former 'black' homelands, an impoverished sector dominated by low-input, labour intensive forms of subsistence production as a key source of livelihood along with migrant remittances and state pensions. This is very much the case in the Western Cape, one of the main contributors of agriculture revenue at national level.

3.1. **The Ebenhaeser community**

The participants of this study are members of the Ebenhaeser community, one of the numerous communities in South Africa that have been dispossessed of their land. This small

Afrikaans speaking rural and coastal community in the Matzikama Local Municipality, in the West Coast District of the Western Cape is located in one of the original "coloured reserve" areas. It is situated in the Olifands/Doorn Water Catchment Area (WMA), and sits within the lowland fynbos biome.

This community was originally settled on the fertile banks of the Olifants river, where they farmed and herded, and had access to extensive portions of land, water and other natural resources in the area since time immemorial. The community was dispossessed of its most fertile land on the banks of the river in 1925 in terms of the Ebenezer (Van Rhynsdorp) Exchange of Land Act No. 14 of 1925, under which the community was granted 11 045 hectares of low-value marginal land as "exchange land" to offset the dispossession - an exchange patently unfair. After a lengthy land claim process, the community has won a land claim settlement of R100 million, the largest in the Western Cape, involving approximately 52 privately owned vineyard farms. (Legal Resources Centre (LRC), 2005a and 2005b). Pending the finalization of the land claim process, the land on which our target community sits is still held in trust by the Minister of Land Affairs, making it effectively still an Act 9 area.

Fig. 10: Ebenhaeser (Geographic Location)
Source: North-South Tourism

Currently, there are approximately 1700 inhabitants in the community (LRC, 2005a), most of whom are largely dependent on their land and natural resources for livelihood purposes (DLIST Benguela, 2012). A preliminary meeting with community members has shown that at least 50% to 60% of the target population is involved in agricultural activities for the purpose of subsistence as well as income generation. Furthermore, community members are aware of

changes in climate patterns and have been able to identify changes in the frequency, length and timing of rain, as well as a continued rise in temperature. These changes are having a negative impact on their local agricultural production, directly affecting their livelihoods.

4. DATA COLLECTION METHODS

Primary data for this study was collected using qualitative interviews, which according to Babbie and Mouton (2001: 132) , are, "essentially a conversations in which the interviewer establishes a general direction for the conversation and raises specific topics raised by the respondents". In the case of this study, the direction and specific topics raised in interviews mirrored the research problematic, and were accordingly sequenced along CC, local knowledge, coping practices, and key livelihood resources.

In order to maximise the quality of in-depth information, as well as improving the validity of research findings, the researcher opted to triangulate data using three types of interviews: individual in-depth interviews, special focus group discussions which included interview partners, and semi-structured interviews. These methods allowed the researcher chances to gather detailed, rich accounts of participants' experiences, as opposed to yes/no answers Marsiglio, 2007). Here, respondents showed themselves to be most comfortable with outlining observed climate changes in the community, as well as its effects on their livelihoods. However, while respondents were able to explain more general shortcomings in their livelihoods, they had some difficulty on their part in describing how changes brought about by CC interact with other local drivers of vulnerability.

In total 15 interviews were carried out over two separate field trips – September 2012 and April 2013. In most of those interviews ocal small-scale farmers were the respondents. During those trips five (5) individual in-depth interviews and two (2) special focus group

discussions (2 participants each), totalling nine (9) local small-scale farmers interviews were conducted, while seven (7) semi-tructured interviews with other relevant local social actors were conducted to gain further insight and complement data arising from in-depth interviews and special focus group discussions.

Furthermore, the choice of respondents was guided along representativeness in terms of gender and age group. It should be noted that different respondents were used to participate in the different data collection methods used in this study (i.e. there was no repetition of participants). All interviews were carried out and recorded personally by the researcher and interview notes were taken during and upon review of interview recordings. All data was collected respecting standard ethical research guidelines.

4.1. **In-depth interviews**

The purpose of in-depth interviews is to explore a general area of interest in depth (Welman *et al.,* 2005). In the case of this study, in-depth interviews were conducted in order to unearth the personal experiences of the respondents in relation to CC, how the phenomenon was experienced and how it was impacting their lives, and how they were coping to date with these changes – individually and as a community. Moreover, as predicted by Greiner (1998), this data collection method proved itself to be particularly useful in probing issues related to the local knowledge of the small-scale farmers.

Following preliminary meetings with community members, the researcher decided to focus on gathering information which is relevant, and rich in quality and depth. For this purpose, the researcher identified key informants in the community, based on the wealth of their knowledge and experience as well as their representativeness of the general conditions of small-scale farming in the Ebenhaeser community. As such, in-depth individual interviews

were used in this study to interview five (5) small-scale farmers from the Ebenhaeser community, most of them elders, including two (2) male farmers and three (3) female farmers. Two of these in-depth interviews were carried out during the second field trip (April 2013).

While it was the interviewee's perceptions that guided the interviews conducted for this study, the researcher was mindful of the fact that in an interview, interviewer and interviewee are not just asking and responding to questions, they are also reacting to each other, which influences what and how the issues are discussed (Welman *et al.*, 2005; Hennick, Hutter, and Bailey: 2011). Guided by an emphasis on frankness and honesty, the researcher attempted to build rapport and establish a position of trust with the participants, allowing participants to express their true opinions without fear of disapproval (Welman *et al.*, 2005). Furthermore, by fostering a loose structure and atmosphere for the interview and guided by the research questions of this study, the researcher was able to suggest general themes of discussion, such as changes in climate, farming practices and local knowledge, or adversities faced by local small-scale farmers in their day-to-day life, giving relative freedom for the respondents to develop their answers, and making use of motivational probes whenever the discussion went off-topic, or when a specific area of interest arose. (Welman, *et al*., 2005; Hennick *et al*., 2011).

Bearing in mind post-modernist views on interviewing as a data collection method stating that the researcher should be aware that information obtained from respondents is influenced by the interviewer's words, ideas, and perspectives (Scott and Garner, 2012), the researcher was mindful in the formatting and posing of questions not to suggest responses to interviewees. For example, in order to unearth agriculture-related CC coping practices as well as impacts and modifications on their local knowledge, the researcher frequently asked the interviewees to compare the present reality to that of the "old days". This was done with the

basic understanding that this comparison would allow respondents to analyse their memories and see changes more clearly. These interviews also shed light on the local realities of the community and how these have an impact on the adaptive capacity of farmers.

Perhaps due to the fact that interviews were carried out in English (second language of respondents) or the often subconscious way in which CC adaptations take place, both the preliminary interviews as well as during individual interviews, there was some difficulty in prompting individual interviewees to produce meaningful information. Nevertheless, this method opened the door to understanding the impact of CC on the local knowledge and livelihoods of local small-scale farmers, and themes arising from data collected on site also helped guiding data presentation and analysis.

4.2. **Special Focus group discussions**

With the abovementioned shortcomings identified in preliminary meetings and in-depth interviews in mind, the researcher planned and conducted two (2) special focus group discussions in an effort to gather more quality data. This method was used to interview four (4) small-scale farmers of the Ebenhaeser community (distinct from those in the in-depth interviews), two (2) male farmers and two (2) female farmers respectively, and in both cases two generations were represented (75+ years of age and 45+ years of age).

According to Luhm (2011), this data collection method, also known as two-person or friendship paired interviewing, is used to reduce the discomfort felt by some in the interview situation, as well as to provide more space for thinking, allowing respondents to build more comprehensive responses through their discussions and enabling respondents to augment each other's stories. This proved to be the case in Ebenhaeser, where the researcher was able to capture much richer answers from the participants in the special focus group discussions in

relation to topics raised previously. This method also allowed the researcher to probe much more flexibly, and to explore unanticipated issues, such as the origins of internal conflict in the community, or the nature and extent of government support and its impacts on local small-scale farmers.

This method of paired interviewing was used in the triangulation of data arising from individual interviews, so as to strengthen the validity of this research. Furthermore, used in conjunction with in-depth individual interviews as well as conducting semi-structured interviews it allowed the researcher to identify possible power differences between the participants (i.e. gender, age, status, etc.), and to explore the degree of consensus on discussion topics, such as the various features of CC and its impacts on the livelihoods of local small-scale farmers (Morgan & Kreuger, 2005, cited in Gibbs, 2007).

Ultimately, this method was very useful for the purpose of this research, not only helping the triangulation of data arising from in-depth and semi-structured interviews, but also, due to its more relaxed nature, it allowed space for the respondents to produce relevant and rich data on how CC affects the local knowledge and livelihoods of local small-scale farmers, and on how male and female small-scale farmers in the community were coping with it.

4.3. **Semi-structured interviews**

Semi-structured interviews were used to interview seven (7) stakeholders, including two government officials (Dept. of Land Affairs, and Dept. of Agriculture) working in the community and two (2) CBO write abbreviation in full when used for the first time workers residing and working in the community, as well as one (1) community worker and activist also working in Ebenhaeser and surrounding communities. These interviews were conducted making use of a list of themes and questions to be covered – the interview guide – on which

the researcher relied to guide the interview, ordering and raising these topics throughout the interview, in case the interviewee did not do it him/herself (Welman *et al.*, 2005; Scott and Garner, 2013). For more detail, refer to the interview guide used to guide data collection in this study (Annex. 1). Two of these interviews were carried out with the same community worker in two distinct periods of time – once in September 2012 and once in April 2013.

This method of interviewing was flexible enough to allow for questions to be significantly modified for individual respondents, while allowing the researcher to improvise follow-up questions as the interview was taking place (*ibid*). It was used in a way to encourage respondents to expound at length in their own words. Also, further questions were asked in order to explore particular areas of interest, such as the physical and infrastructural settings of the community, and clarify possible vague responses (Welman *et al.*, 2005; Scott and Garner, 2013).

These interviews were conducted before, during and after the in-depth interviews with small-scale farmers, with a view to not only gather information and understand the local and historical context in which the community, and local small-scale farmers in particular are established, but also to probe specific issues or gaps in information that arose during the field-work, such as information complex issues related to local water infrastructure, distribution and management of irrigation sessions. Information arising from these semi-structured interviews was vital in the researcher's effort to draw a realistic picture of the context in which this study's problematic is inserted.

As I explained in the following chapters, the degradation of farming conditions in Ebenhaeser meant that many of the local farmers were searching for sources of income outside of town, frustrating the researcher's attempts to interview as wide a sample as possible.

Nevertheless, data arising from both field trips using the above mentioned methods provided sufficient material for the analysis of the problematic of this study. Used together, the triangulation of the abovementioned data collection methods ensured validity of research findings, allowing the researcher to draw a realistic picture of the features and impact of CC on the bodies of local knowledge and key livelihood resources of the small-scale farmers of the Ebenhaeser community and how these interact with the local context within which this problematic is inserted. This picture will be drawn in Chapter 4 and analysed in Chapter 5 of this study.

5. DATA PRESENTATION AND ANALYSIS

The data collected using the abovementioned data collection methods is presented in terms of both analytical frameworks presented by the researcher in the Conceptual/Theoretical Framework section of Chapter 2 of this study.

The theoretical framework depicting the dynamic process of development of local knowledge-based CC coping practices by small-scale farmers (see Fig. 9) is used to guide the logical flow of the presentation. Additionally, Riché *et al.*'s (2009) framework (see Table 1) assisted in the identification of the various components of the vulnerability of the livelihoods of local small-scale farmers as elements of the sequence depicted in the main framework. As such, in presenting the vulnerability of the rural livelihoods of local small-scale farmers, recourse is made to key livelihood resources (natural, physical, human, social, and financial), and their relation to the exposure and sensitivity displayed vis-à-vis CC.

Other than these two main frameworks, the researcher also made use of various instruments in order to illustrate the concepts which are key to this study. Various graphs and projections were used to illustrate CC at global and regional levels (see Fig. 1 and Fig. 2 in pages 12-13),

and some of its main indicators, i.e., precipitation and temperature, at national and at local levels (see Figs.3, 4 and 5, and Fig. 6). The researcher also made use of a Venn diagram illustrating the nested hierarchy of vulnerability of small-scale farmers (see Fig. 7).

Finally, in order to understand the vulnerability of small-scale farmers to CC and how it plays out within the context of the above mentioned theoretical frameworks, the researcher made use of a vulnerability framework illustrating the relationships between vulnerability and its components of exposure, sensitivity, and adaptive capacity, and how they interact with the underlying drivers of vulnerability to determine the impact of the hazard (in this case, the various features of CC) on the key livelihood resources and the available coping practices. These features ultimately determine the level of vulnerability of any given community to any given hazard, such as CC, in the case of this study (see Fig 8).

The researcher used secondary as well as primary data and processed it using analytic inductive and deductive procedures to arrive at a clear, trustworthy and insightful analysis of collected data (Gibbs, 2007). As such, qualitative data generated during the desk-top study, as well as individual in-depth and semi-structured interviews and special focus groups were analysed using thematic ordering and systematization, which according to Ryan and Bernard (cited in Welman *et al.*, 2005), is one of the most fundamental tasks in qualitative research. These themes were identified and arose before, during and after field work had been undertaken and were guided by the literature review and the theoretical and conceptual frameworks.

By absorbing the conceptual frameworks into the logic of the theoretical framework of both frameworks presented in the literature review chapter of this study, and subsequently in the thematic ordering and systemization of data collected, the researcher was able to analyse and understand the different components of the impacts of CC and their interactions in a more focused manner, facilitating a clear view of the dynamic process of development of local

knowledge and CC coping practices by the small-scale farmers of the Ebenhaeser community. And whilst this constituted the formal and conceptual level of the research i.e., opening up the relation of CC to local knowledge and coping practices with a view to understanding its impact on the key livelihood resources of small-scale farmers of the Ebenhaeser community. In doing so, it has invoked the substantive dimensions of the research problematic.

Thus most noteworthy, in placing CC in perspective i.e., producing a realistic picture, is the particular emphasis in the data analysis given to the interactions between CC and the vulnerability of the livelihoods of local farmers (expressed through their reference to the key livelihood resources). These features are referred to as the underlying drivers of vulnerability, i.e., features of the socio-economic and political environment of the community. However, notwithstanding the important role such drivers play in the extent of the mediation of the impact of CC on the livelihoods of local farmers, these underlying socio-economic and political features were also found to have explanatory value in accounting for hindrances to the adaptive capacity of local small-scale farmers to CC.

6. VALIDITY

Validity in qualitative research, relates to whether the findings of the study accurately reflect the real situation, and whether there are no good grounds for doubting the results; i.e. the weight of evidence supports the researcher's conclusions (Giuon, 2002), and can be divided into *internal validity* and *external validity* (Colorado University, 2012).

Internal validity of this study will be tested not only by triangulation of data collection methods, but also by matching the patterns of the reactions of small-scale farmers to CC. As indicated in the literature review, most of the responses of small-scale farmers to CC involved

changes in agricultural practices and local knowledge, on- and off-farm diversification and migration. If such patterns are observed, internal validity is demonstrated. Furthermore, the patterns shown in the case of Peruvian small-scale farmers or of the Kereita Forest lend face validity to this study. External validity will be ensured by using data triangulation of data arising from different data collection methods, i.e., individual in-depth interviews, paired in-depth interviews and semi-structured interviews.

7. CHAPTER SUMMARY

In this chapter the researcher outlined the research design and methodology used in the study.

This study was conceived and planned as a qualitative research project, making use of three different qualitative data collection methods, i.e. individual in-depth interviews, paired in-depth interviews (special focus groups) and semi-structured interviews, to interview a total of 14 individuals. Data was analysed using thematic ordering and systematization, as well as basic quantitative methods.

Finally, the researcher drew some key considerations regarding the internal and external validities of this study. The following chapter will be devoted to the presentation of research findings.

CHAPTER 4

DATA PRESENTATION

1. INTRODUCTION

The data findings in this chapter are presented in terms of the theoretical framework presented by the researcher depicting the dynamic process of development of local knowledge-based CC coping practices by small-scale farmers in Chapter 2 of this thesis (see Fig. 9).

As such, the presentation of data starts by outlining data collected in relation to the CC in the Ebenhaeser community as perceived by local small-scale farmers, which is followed by the data collected in relation to the key livelihood resources of local small-scale farmers, as well as that of other aspects of the Ebenhaeser community that are important for this study's problematic. The researcher then moves on to present data collected in terms of the impacts of CC on the aforementioned key livelihood resources.

Finally, the researcher presents the coping practices developed by local small-scale farmers to cope with the identified impacts of CC on their livelihoods, as well as the different bodies of knowledge used to inform such practices. The next chapter (Chapter 5) will present the analysis of this data.

2. CC IN EBENHAESER

All interviewed farmers were in agreement about the occurrence and features of CC in their community. In line with reviewed literature, interviewed farmers were unanimous in pointing

out the various changes in climate features. Furthermore, in consistency with reviewed literature, these changes in climate were seen by respondents as clear indicators of CC. These features are presented in the following paragraphs, and, through the lens of this study, constitute their **exposure** to CC.

2.1. Shift in seasons' timing

A **shift in seasons' timing** was the first change identified by most respondents.

Local farmers from Ebenhaeser were unanimous in pointing to a 1 month delay in the summer planting seasons, stating that whereas the summer planting season used to start in mid-August, now it only starts in mid-September. This change was also evident in the winter planting season, where it shifted from mid-April to mid-May.

2.2. **Unpredictability of the seasonal weather**

The **unpredictability of the seasonal weather** was also acknowledged by all farmer participants, with at least one farmer stating that fruit tree cycles are changing, stating that some trees are flowering in May/June, the supposed beginning of winter. According to him "it is the first time [I] have seen tree flowering like this in winter". One farmer went as far as to say that "nowadays you can't even tell what season it is anymore!" Also, unpredictable off-season rains (such as the one which occurred during field trip) are something that never happened before. According to one surprised farmer, "I have never seen it rains like this in my whole life!"

The farmer went further to explain that whereas in the old days rain volumes would be constant throughout the years, nowadays there is great variability in rain volumes for

equivalent periods. According to him, "nowadays you can get, "say" 50ml for a given month, then next year you can get 10ml, and 30ml in the next […]. It is unpredictable."

Unusually hot days and cold were also reported. Whereas the normal temperature in Autumn ranges from 18ºC-25ºC, respondents mentioned the occurrence of very hot days, with temperatures ranging from 35ºC to 40ºC in March (mid-Autumn). The opposite also happened. As explained by one of the respondents "just the other day, we are not used to getting this wind coming this time of the year. I mean here it felt like winter! And it is still autumn now." Another farmer explained that, "now, in winter temperatures are just unpredictable."

2.3. **Change in rain patterns**

Changes in rain patterns were also mentioned by all farmer participants, with farmers explaining that while winter rains used to be constant in the old days, nowadays there is great variability in rain volumes for equivalent periods in the latest years. Farmers went on to report that there was almost no rain in June and July in the last couple of years, something they had never witnessed before. As explained by one female farmer, "it used to rain for the whole month at this time of the year. Last year we only had two good rains at this time."

Also, whereas the normal rainy season lasted from April/May to August/September, covering autumn and winter (with stronger rains in winter), now "it rains in April and May then stops until October and it rains some more". Two female farmers agreed and corroborated, indicating that as opposed to the typical "8-day rain every two weeks", in the last few years " if it rains, it rains a lot for a day, then it doesn't rain again for months". It was also explained that there used to be rains with some frequency up to September. Nowadays they can't be sure if it was going to rain.

On the other hand, in summer (December to February) the normal conditions were no rains, with normal temperatures ranging from 30ºC to 40ºC, with isolated strong, unpredictable rains and thunderstorms. Nowadays, they said, "It rains like in winter, and [we] are getting unusually strong winds."

Additionally, one respondent also mentioned that spatial rainfall patterns and climate conditions I were ncreasingly occurring differently across the community, citing the example of an instance when, "it was sunny and warm here in Nuwestasie and then it was cold and with heavy fog down there in Olifantsdrift" (see Ebenhaeser map in Annex 1), explaining that something like this had never happened before.

2.4. **Increase in frequency and intensity of cold and warm, and an overall increase of average temperatures**

Farmers also mentioned a general **increase in frequency and intensity of cold and warm days** throughout the year, describing that, "nowadays its gets very hot and then very cold, very quickly!" One farmer pointed out that nowadays temperatures in winter can rise up to 30ºC. Another farmer explained that cold days were becoming ever colder.

Additionally, in referring to an **overall increase of average temperatures**, for example, where in winter (June to August) temperatures used to range from 13ºC to 20ºC, winters were much warmer nowadays, with temperatures ranging from 20ºC-25ºC. As put by one female farmer, "you can't even believe its winter." Another farmer added "these days the weather is just too hot!"

2.5. **Reduction in the amount of rainfall, and** a **decrease in frequency and intensity of rains**

Finally, a general **reduction in the amount of rainfall** along with a **decrease in frequency and intensity of rains** was also identified by respondents. Where in winter (the rainiest season) the community would normally get plenty of rain throughout the season, in the last years it had only been raining at a rate of 10 days out of 30.

As noted by one respondent, "for example, in the last years we haven't been having rains in June or July [winter]." A female farmer complimented this, stating that**, "it used to rain for the whole month at this time of the year. Last year we only had 2 good rains at this time** [winter]."repetition Another farmer added that the community had only experienced " three good rains in the last four years". One respondent also mentioned that as a result of less rains, the river levels had been lower in recent years.

Table 2 below summarizes the climate characteristics of the Ebenhaeser community and the changes in terms of temperature and rain patterns identified by respondents.

Table 2: Seasons and Features – Past and present

Season	Period	Rains	Temperature
Spring	September to November	**Before:** some rains into September. **Nowadays:** they are not sure if it is going to rain at all.	**Normal temperature:** around 20ºC-25ºC. **Nowadays:** they community have been experiencing unusually hot and cold days.
Summer	December to February	**Before:** no rains in summer, with the exception of some very strong, unpredictable rains and thunderstorms. **Nowadays:** winter-like rains with the occurrence of unusually strong winds.	**Normal temperatures:** from 30ºC to 40ºC. No significant changes in summer temperatures were identified.
Autumn	March to May	**Before:** rains start in the end of April/mid-May. **Nowadays:** Rains start in the end of May/April	**Normal temperatures:** temperature starts dropping, with temperatures ranging from 18ºC to25ºC. **Nowadays:** unusually hot days in March, with temperatures ranging from 35ºC to

			40ºC. Winter-like cold winds.
Winter	June to August	This is the rainiest period of the year. **Before:** plenty of rain throughout the season. **Nowadays:** in average 10 rainy days out of every 30.	**Normal temperatures:** ranging from 13ºC to 20ºC. **Nowadays:** the average temperatures have risen significantly (20ºC-25ºC), Temperatures are unpredictable, with some days reaching up to 30ºC.

Table 3 presents the identified changes in climate in Ebenhaeser, organized in term of the main characteristics of CC covered in the Literature review chapter of this study.

Table 3: Identified features of Climate Change in the Ebenhaeser community

Climate Change	Identified features
Shift in seasons' timing	• 1 month delay in the summer planting season, from mid-August, to mid-September. • 1 month delay in the winter planting season shifting from mid-April to mid-May.
Unpredictability of the seasonal weather	• Unpredictable off-season rains • Unpredictable fluctuations in monthly rain volumes • Difficulty in distinguishing between seasons • High temperature variability
Changes in rain patterns	• Changes in patterns of winter rains • Winter-like rain and wind in summer • Changes in spatial rainfall patterns and climatic conditions across community
Increase in frequency and intensity of cold and warm days	• Cold days are becoming colder • More frequent and intense variations in temperature
Overall temperature increase	• Weather is getting warmer and warmer across seasons
Reduction in the amount of rains	• Substantial reduction of winter rains • Decrease in frequency and intensity of rains

3. KEY LIVELIHOOD RESOURCES OF LOCAL SMALL-SCALE FARMERS

3.1. **Natural Resources**

There are officially 153 agricultural plots in the Ebenhaeser community, sizing on average 1.8ha each, as well as 6ha of government **farming land** currently being utilized by a women

community farmer group. For grazing purposes, there are 15 separate grazing camps in the community's surroundings, totalling an area of approximately 16000ha.

Apart from the government farming land (women's project), all plots in Ebenhaeser are irrigated by an irrigation channel originating in the Clanwiliam Dam. Conversely, all plots in the community (excluding the government farmland) have water and grazing (in nearby designated grazing areas) rights attached and land usage varies between farming, grazing, or a mix of both, depending on plot conditions and tenant capacity. Some of the plots maybe parcelled and sub-let by land owners.

Additionally, the community also has access to fishing rights. Although the allocation process was initially facilitated by Cape Nature, which would organize a committee in the community to jointly allocate the rights within community members. Cape Nature has since pulled out of this process, and the community itself now organizes this process. Although the researcher had no access to it, there are certain criteria on which the community committee rely to select "beneficiaries". Initially there were 60 fishing rights holders, but with changes in net size licenses requested by the community, this number was reduced to 45 rights holders.

In relation to water resources, apart from rain water, irrigation water supply to the community is structured in such a way that the water is sent from the dam in bulk, at a measure of 60000l per water-right holder per year (the government standard for water consumption per hectare). Since there are no meter systems to measure how much water is actually used on each plot, no actual measurements have been taken to confirm this amount. In the words of a local community worker, "this is one of the main problems of this community." The water is measured in amount per hectare, as opposed to m^3.

For a 1.8h to 2h plot, depending on the crop, farmers flood irrigate their fields (given that there is a normal flow of water) for 8 to 10 hours per irrigation session. Farmers rely on their

farming knowledge to determine when the soil is wet enough. This equals an estimated amount between 2 and 3000l per hectare. Due to the lack of measurements, this number was calculated by dividing the total water allocation for the community among the plots in the community. The lack of measurement also leads to the uneven distribution of water within the community, aggravating the water availability problem.

On the community farm, initially catering for 40 community members, most of them with no land rights and divided into two groups, but now down to only eight, a water pump was to pump water from the river onto the farm. Although this water is not yet enough to cover the full potential of the farm, it is "better than nothing", as put by one of project's female farmers.

However this facility can only be used when the river levels are high enough, which happened less and less often in the last 3 to 4 years. Normally, the river levels would be high enough throughout winter (May/June-August/September). With the reduction in rains this pattern has changed. More sporadic rains in winter and unpredicted strong rains in summer meant that last year the river flooded three times, for periods no longer than two-weeks. The last big flood was in 2008. At the time of the second field visit, the group was still waiting to hear from the Municipality about the approval of their permit to pump water from the river on a more regular basis. According to our local community worker, "it shouldn't be a problem to get this authorization since the land will belong to them eventually", and this is a common practice on other farms along the river.

3.1.1. **Household food gardens**

Although this practice is growing out of fashion, many farm households still have such food gardens at their homes. As explained by civil society workers, this practice is most common in the poorer areas in the outskirts of the town. Nonetheless, five of the farmer respondents

confirmed having a food garden for household consumption. Apart from having various fruit trees, they normally plant crops like tomatoes, onions, garlic, carrots, pumpkins, sweet potatoes, beetroot, etc.' ultimately, as one female farmer put it, "things that you can use at home straight away". Two female respondents concurred in explaining that they may sell household produce in small quantities in order to cover for household expenses, such as electricity, and the like.

3.2. **Physical Resources**

The main **physical resources** on which local small-scale farmers depend include the local irrigational system, as well as the government-run agricultural support centre.

3.2.1. **Irrigation canal**

In relation to the irrigation system, the majority of the farming plots in the community are serviced by the local irrigation canal, with water supposedly running for periods of two weeks every second week throughout the year. Some of the interviewed farmers stated that this did not take place, especially during the dry summer months, making small-farmers' livelihoods hard. All interviewed farmers mentioned problems with water supply.

According to a government official from the Department of Agriculture working in the community at the time , this problem was exacerbated by the State and quality of irrigation infrastructure in Ebenhaeser. As reported by a local community worker, the decaying condition and lack of maintenance of the Ebenhaeser irrigation canal was evident. As explained by him, "most of the irrigation channels are open channels and run on the ground (as opposed to in a pipe or on cement). This means they lose significant amounts of water

through evaporation and seepage". The deterioration of the infrastructure made s water loss worse.

Having identified the need for a new irrigation system to be installed, the government has a plan for a R30million system (pipe system) which will provide a water point on every plot, while vastly reducing the water wastage evident in the current irrigation system. It will cost R15000 a year per farmer for farmers to use. According to a government official who was interviewed, this irrigation system was planned to be ready by June 2014. At the time of the study period there was also a plan to increase the walls of the Clanwilliam dam in order to increase its capacity, although no deadlines had been put forward. Although the river has other tributaries past the dam, this upgrade will have the potential downside of affecting river water levels below the dam, potentially affecting those who depend on the river for a livelihood.

Nevertheless, the representative of the Dept. of Agriculture explained hat a recent upgrade was made to the irrigation system in 2011, which consisted of the construction of a balancing dam which was supposed to cover r the needs of farmers in case of shortages. Although local farmers were negatively affected by water shortages that occurred during the construction of the dam, its impact in farming in the community would be observed throughout the coming season. The Department of Agriculture also recently installed individual water reservoirs in the Nuwestasie area of the community to improve water management. This programme had not yet been extended to the whole community. Surprisingly so, after a second visit to the community, informants informed the researcher that the effectiveness of this initiative had been reduced.

Additionally, with the assistance of EPIOS, a local CBO, local farmers managed to secure funds and build an irrigation pipe to serve the Olifantsdrift section of the community, which greatly reduced water loss, to the benefit of the local farmers in that area.

In terms of **water distribution**, it is the governing body's responsibility to transport the water (through a canal) up to the community limits. From there on it is the responsibility of the community itself to organise and create a structure that can manage irrigation water distribution to the various farms in the community in a way that benefits all local farmers equally.

Many attempts had been made to establish such a structure, but according to two community workers the importance of water as a resource coupled with the lack of skill available and conflicts of interest (in most cases where the chair of the organisation is also a water right holder) repeatedly failed.. A community worker opinion was, that, if this structure was to succeed in its mission, farmers must create a structure that is independent and capable, and "farmers have to find a way to work together for the benefit of all".

The serious issue of management and distribution of irrigation water was mentioned by all respondents and had been causing considerable tensions among farmers. As pointed out by one male farmer, it was not necessarily the case that there wasn't enough water for everyone especially for those situated on farms towards the south as well as the west of the community (see Ebenhaeser map in Annex 1). Rather, the uneven distribution and management of local irrigation water was at the heart of the problem. This had a negative impact on the agricultural production, and thus the livelihoods of small-scale farmers in the community, especially those whose plots are located further down the irrigation canal were seriously compromised.

As far as **irrigation techniques** go, 80% of farmers in the community use flood irrigation in their fields. Although this ends up eroding soil of a few farmers, the vast majority have a good knowledge of the technique and use it correctly, with no negative effects.

Ultimately, the insufficient and irregular water supply still being a reality in the community at present means that most small-scale farmers in the community are significantly dependent on rain water for their farming, and therefore, for their livelihoods.

3.2.2. **Agricultural Support**

In 2005, soon after taking over from the traditional council which used to administer Ebenhaeser, the Municipality started providing agricultural support to small-scale farmers in Ebenhaeser. This assistance comes mainly from the Department of Agriculture, and is aimed at improving their farming and livelihoods. Other than soil PH and salinity testing and general agricultural support, the centre offers agricultural mechanisation support in the form of tractor services and agricultural implement rentals. EPIOS, a community-based organization operating in the community also provides tractor services at low cost for local farmers. The following were the going prices for the agricultural services offered to farmers in Ebenhaeser during the research period :

- **Tractor hire**
    - EPIOS – R150 p/ hour (tractor + driver)
    - Municipality – R180 p/ hour
- **Driver** – R30 p/ hour
- **Cutter and raker** – R20 p/ hour

- **Bailer** – R110 p/ hour

The following conditions were set. All implements had to be rented from the Municipality. Local farmers, especially those planting lucerne, had to do this every month. The average time it takes to harvest a plot in Ebenhaeser (1.8h to 2h) is 1.5 to 2 hours.

However, misuse and bad maintenance of the centre's equipment and implements were reported to render the service unreliable, especially in the case of the tractor rental., The local department of agriculture decided to stop maintaining their equipment, reportedly based on the financial sustainability of the initiative. According to one farmer, this unreliability had a negative impact on the agricultural production of small-scale farmers in the community.

It must be noted that numbers of users of these services had reached an all-time low morale. Between both the Municipality's and EPIOS's services, the normal number of about 120 users per season dropped to close to 50%. No more than 60 users participated in the last season.

On average, about 70 farmers used to rely totally on the municipality tractor. At the time the report was prepared, the number was down to fewer than 30, perhaps even fewer, because the municipality stopped paying for the maintenance of their equipment.

Despite alleviating some of its effects, no government or civil society programmes operating in the community were focusing directly on or had components dealing with CC and its impacts on the community, and on local small-scale farmers in particular.

3.3. **Human resources**

As far as **human resources** go, the extensive history and experience of farming and herding in this community means that apart from their own and occasional hired labour, the main

human resources on which local small-scale farmers depended were their bodies of local knowledge, namely those related to farming, herding, climate and the surrounding natural environment.

Although compiling a full inventory of local knowledge bodies was not an objective in this study, all farmers interviewed displayed evidence of their local knowledge. Citing the example of a local CC coping practice related to the ideal conditions for bean planting, farmers were comfortably able to explain the conditions necessary for a successful crop, explaining that they "watch the weather" and gauged soil temperature to know if planting and harvesting conditions were appropriate. According to one female farmer, "the warmth of the ground will tell you when it is time to plant." Conversely, they must know when it is going to rain in order to time the harvesting of potatoes or cutting and bailing of the Lucerne (lucerne must be left in the field for up to a week to dry before bailing). One female farmer describing farming activities that take place in the women farmer agriculture project explained, "This knowledge is second nature to farmers here. We know how to work the land. We know what to do."

Overall, the grasp and wealth of the local farming, herding, climate and environmental knowledge bodies utilized by local small-scale farmers transpired through the detail they were able to provide, not only about current changes in climate, but also about how CC affected their farming activities and what CC coping practices they had developed.

3.4. **Social resources**

The long history of disempowerment and internal conflict has meant there are very few social institutions in Ebenhaeser to cater for the various interests and needs of local small-scale farmers. Nevertheless, local lucerne producers took the initiative to form a cooperative in

order to have better bargaining power in the sale of this product, as well as strengthening local production. But this was not off the ground yet, and no specific deadlines had been set.

The local women farmer group, with the support of the National Development Agency and EPIOS, had been playing an important role in the community through their current engagement in a food production project mainly directed at alleviating the need of poor, food insecure, local households. The project's aims were to produce food (mainly in the form of vegetables). They would use a 40-60 split between home consumption and support to the community, and sale to the market. Nevertheless, generating income for the participants was a strong objective of this project.

Additionally, community based organisations (CBOs) played a key role supporting local small-scale farmers. Such was also the case of EPIOS, whose support ranged from the provision of a tractor for rental at affordable prices, to agricultural input support (seeds, herbicides and pesticides.) to fundraising for irrigation system upgrades and capacity building activities. The organisation also supported and assisted the women farmers' project, and planned to purchase farm implements to cover the gap left by the closure of the Municipality services.

Other than the aforementioned, government, mainly the local Department of Agriculture, provides the largest share of agricultural support to local small-scale farmers. Through its farmer support centre as well as other support programmes, this institution provides agricultural services such as tractor and implement rentals, soil PH and salinity testing and other agricultural support (subsidies, workshops, seminars). Additionally, various government-led capacity building initiatives are and have been taking place in the community, ranging from chemical use in agriculture through to marketing strategies and conflict resolution. It is noteworthy that the Municipality, the Department of Agriculture and EPIOS have been the only institutions supporting small-scale farmers in this community.

In terms of the youth, very few are involved in farming. This is partly caused by the fact that only the elders in the community have land rights, meaning that if a youth wants to get involved in farming, he/she has to partner with someone who has land. Nonetheless, farmers still do generally count on the help of family for busy months (sowing and/or harvesting).

3.5. **Financial resources**

While agriculture is the most important activity in the community, most farmers in the community own livestock (mostly sheep) to utilize their (or their landlords') grazing rights benefits. Apart from the few women who are still working the land on farms they inherited from their diseased husbands and those engaged in the aforementioned women farming programme, men form the majority of farming for income generation in the community.

Additionally, most respondents at some level depend on government pensions to support their livelihoods. Given the extent of their dependence on agriculture, the following subsections will cover the data collected in relation to farming for income as well as for household consumption, and herding. Although a few farmers in the community do hold fishing rights, the percentage is very small, and virtually no data was available on this. As such, this activity is not featured as a key financial resource of local small-farmers.

3.5.1. **Summer cash crops**

While some crop choices have changed overtime, mostly due to technological and market access and for demand reasons, the most common summer crops (September to February) mentioned in interviews include potato, butternut, squash, pumpkin, onions, sweet potatoes

and beans. Nevertheless, these varieties have been cultivated by local farmers over a long period of time, so they have a well seated knowledge base on how to grow them.

Farmers plant different crop combinations and make an effort to avoid duplication of other farmers' produce, aware of the negative effect that a flooded market has on their produce prices. Some farmers sell half of their produce and keep the rest for personal consumption; others prefer to make as much profit from their produce as they can. As a result, farmer households complement their dietary needs with produce from household gardens or by buying produce from other farmers and the few local shops. While in the case of beans production, most, if not all, farmers are producing it on contract for the PANNAR seed company Most agricultural produce is sold within the community or to supermarkets in nearby towns (Lutzville and Vredendal). Although the scale of this project made it impossible to get detailed data on vegetable production in the community as a whole, data from the community farm illustrates the sharp descent in production levels and income of small-scale farmers in the Ebenhaeser community in the recent past.

According to this data, in its inception year (2011), with full support (including a monthly stipend for beneficiaries), plenty of water, and good weather, the project harvested 46 tons of tomatoes, 4 tons of beans, 120kg of pumpkins, 1.4 tons of onions (700 bags), and 700 bales of lucerne (which is supposed to cover the running costs of the operation), earning them just under R127000.

In its second year (2012), with the stipends cut, bad weather, water problems, as well as marketing problems, the project only managed to harvest 12 bags of onions, lost the whole of the beans production for the season, sold cabbage production at 20% of the normal price (R1-R2 as opposed to R5-R6), earning them about R350, apart from the normal lucerne

production (+/-R30000). This makes a total income of no more than R32000, a sharp reduction compared to the previous year.

In its current year (2013) the group decided to not risk more losses and only planted lucerne. No numbers were available at the time of the final field visit.

According to key informants this decline in production is a parallel of the situation in the wider community. As pointed out by a community worker, no more than 40 farmers were planting that season, other than the 4 larger-scale farmers who, leasing land from local rights-holders, were currently cultivating a total area of approximately 14 hectares. The informant goes on to explain that those who are planting, are concentrating mostly lucerne and some vegetables, including pumpkin, squash, butternut, potatoes, onions and sweet potatoes, some of which, for own consumption.

3.5.2. **Winter cash crops**

As far as **winter crops** go, apart from one farmer who stated that he also plants potatoes and sweet potatoes (red- and white-skinned) between March and April to take advantage of the high price of the produce in June (the peak of winter), the vast majority of farmers dedicate their plots to planting animal feed.

3.5.2.1. **Lucerne**

The crop of choice across the community is a combination of lucerne (*Medicago sativa*, also known as *alfalfa*) and either oats (*Arena Sativa*), or barley (*Hordeum vulgare*), using the centuries old method of intercropping. This combination is used because the oats and the barley give protection against sun and wind to the smaller lucerne plants. Besides that, this combination also greatly increases the nutritional value of the sheep feed and has been

known in the community for a very long time. However, this combination is not for market sale, as it is only possible when planting/replanting lucerne. Hence, local farmers only do this when it's time to replant their lucerne fields (every 3 to 5 years).

Lucerne is normally planted in April, to time it with the start of the rainy season (April to May), with the first cut being made an average of three months after planting (August). This first cut is not of market quality and can't really be sold, so farmers feed it to their own cattle. From the second cut on (which is cleaner) farmers can sell the production. It can then be harvested every month, with an average production of 80 to 100 bails per hectare, meaning that the average local farmer would produce 200-300 bails per season.

Lucerne lasts an average of 3-4 years for the "standard" variety and up to five years for the improved (more expensive variety). The latter has a lower yield but lasts longer. Although farmers may choose to pull it out at any given time, if they feel they have a better product to plant, this is usually not the case, especially for individual farmers.

Sowing is done with a manually operated 'seeder' planter and harvesting is done by tractor. The harvest is done in three parts: cutting, raking, bailing. In the old days this was done using horses, but now the process is mechanised.

One farmer explained that although local farmers have been growing this mix for a long time as a means to supplement herd nutrition, over the years the market demand for this crop has been growing. The price of lucerne has upped from R3-R4 a bail in the 1970's to R25 to R30 nowadays. Although this is the normal buying price, if the quality of the lucerne is not so good, prices can go down to R20-R25 per bail. It must be noted that this is not the final market price, as a lot of the local production is bought by middlemen, who then resell the bails at up to R50 per bail. Produce is sold locally and to the surrounding communities, as well as at further areas such as Lamberts Bay, Louriesfontein and Klawer.

Depending on the variety of lucerne farmers decide to invest in, it can grow continuously for a period ranging from 5 to 8 years as mentioned above, and harvest is mostly sold within the community and in surrounding towns and villages. According to the farmer, "Now they want lucerne!" Nevertheless, this increase in demand, along with other factors, has also meant an increase in the price for lucerne seed.

Some farmers also diversify their produce by planting different varieties of beans either during winter or throughout the year.

One reason farmers plant lucerne in winter is that it takes three months until it can be harvested for the first time. Farmers use the winter period for that because to *veld* is rich in the rainy winter season, providing plenty of feed for the sheep. Farmers buy input seeds and store the final product by compressing it into bails, stacking and covering it to protect against the elements. Furthermore, according to one farmer, its relatively low labour-intensity nature makes lucerne an attractive crop to plant all year-round.

In order to harvest the crop, farmers have to cut it down and leave it to dry in the field for 7-10 days before the final harvesting and bailing can take place. It is crucial to have dry weather during this drying period, as the moisture can spoil much if not all of the harvest. As put by one male farmer, "You cut, then you pray for good weather!"

Table 4 below presents the main crops planted by small farmers in the community.

Table 4: Main crops of Ebenhaeser small-scale farmers

Variety	Planting season	Planting time	Harvesting time	Cycle
Pumpkin	Summer	**m**id-October	February/March	4 months
Carrots	planted throughout the year			
Onions	planted throughout the year			
Beans	Summer	January/ February	March/ April	3 months
Red-skinned sweet potatoes	Summer	January	March/April	3 months
White-skinned sweet potatoes	Summer/winter	January	June/july	6 Months
Tomatoes	Summer	September/October	December/January	2-3 months
Potatoes	Throughout the year	February October	June January	4 month
Lucerne	Winter (once every 3 to 5 years)	April	July (first cut) Monthly after the second cut	3 to 5 years (depending on variety)

Although farmers have traditionally used animal traction for performing most farm tasks (soil preparation, sowing, planting, harvesting, etc.), more and more farmers are switching to the use of tractors. Despite being more costly, this practice makes work in the fields much less straining. Most farmers using animal traction (like the women group working on the government farm) do so because they cannot afford the tractor service.

3.5.3. **Herding**

Apart from farming, the original communities inhabiting this region were great herders that would roam around the plentiful grazing lands to feed their livestock (mostly sheep), deriving a relatively prosperous livelihood from it. Female farmers explained that best sales take place around festive seasons, i.e., Christmas and Easter (high-season), and farmers often sell livestock to complement their income.

Apart from the high season, another important event in the sheep herding season is the ramming, which consists of introducing rams (male sheep) into ewe (female sheep) droves for mating (rams and ewes are usually kept separately). They have the same practice for

cattle. By using this method, farmers ensure that ewes and cows are pregnant during winter, when grazing is plentiful, and they are able to control the timing of births, ensuring that calves and lambs are born in spring (after the coldest period), improving the chances of success of the calf herd and lamb flock. Herding animals, sheep in particular, is a tradition in Ebenhaeser. As such, all families that can afford their own sheep, have flocks, even if only for traditional reasons.

Herding of animals in the grazing areas is performed by pre-designated herdsmen, and farmers visit their animals on a regular basis to ensure that all is well. During the warmer months (when the weather is driest and grazing fields are diminished), sheep are brought from grazing areas to the property where they are usually fed the lucerne mix. This is usually done every year, for a period of two months, and is a chance for the farmers to have a look at their own livestock and make sure every animal is healthy. Table 5 below summarises the data collected in relation to the key local livelihood resources of the small-scale farmers of the Ebenhaeser community in terms of Riché *et al*'s (2009) suggested livelihood resource categories.

Table 5: Key Livelihood Resources of the small-scale farmers of the Ebenhaeser community

Livelihood Resources	Key Local Resources
Natural	Household food Gardens Farmland Grazing fields Water sources
Physical	Irrigation infrastructure Agricultural Mechanisation Centre
Human	Local knowledge (farming, herding, climate, environment) Labour
Social	Women farmers group Local CBO's Government Support

Financial	Livestock Crops Agricultural Subsidies Pension

4. OTHER KEY ASPECTS OF THE EBENHAESER COMMUNITY (UNDERLYING DRIVERS OF VULNERABILITY

Apart from the aforementioned, there are other important aspects of the local setting that influence local farming activities, having a direct impact in the livelihoods of local small-scale farmers. These include aspects relating to the historical context of the Ebenhaeser community, the nature of farming support and its effects, issues related to market access (or lack thereof), issues linked to the gendered division of labour, and issues of community cohesion and cooperation. These aspects have the effect of increasing the exposure and sensitivity of the livelihoods of local small-scale farmers to CC, as well as reducing their adaptive capacity.

4.1. Historical context

Modernity has changed the community in many ways, affecting many aspects of community living. As explained by one female farmer, "back then [our] people used to make everything by themselves, build their houses, farm, herd. Nowadays it's not like that anymore…" In agreement with this statement, a male farmer reported that, "[we] can't plant like we did back then…" Another female farmer also pointed out that this has a significant effect on the outlooks that younger generations have on the future of their community.

In historical terms, the 153 original plots in the community were given to the heads of families recognized by the *apartheid* government as original inhabitants of the area as compensation for the recently usurped land at the river banks. This process of identification

of "recognized original inhabitants" by the *apartheid* government, which is reported to have been characteristically skewed, contributed to the impoverishment of the community, as well as to the development of a conflict-prone environment in the community. Furthermore, title deeds were issued to male heads of household only, further entrenching gender divisions. Such decisions were typically taken without paying any consideration to the realities of the communities, and their negative impacts can still be felt today.

Furthermore, in the old days many different sheep species were kept and there was never a shortage or limit to the number of animals owned. The removal and re-settlement that took place changed all of this. The demarcation and enclosure of grazing areas (part of betterment planning measures, and a system totally foreign to local herdsmen) along with legislation prohibiting free grazing have crippled the local herding activities and culture of the re-settled community, bringing it to a virtual halt, severely limiting this community's vital sources of livelihood. As explained by one farmer, whereas in the old days farmers would have up to 300 or 400 sheep, nowadays, due to the limited available grazing land and as prescribed by the DOA, farmers are only allowed 13 sheep per grazing rights holder. The farmer explained that this was not enough animals to make up the number needed for a herd, as the costs of maintaining a herd means that one needs to have at least 50 sheep in order to "break even". One farmer went on to say that many farmers own more sheep than they are allowed to.

Farmers also reported that nowadays a lot more theft of livestock takes place, which is something that didn't take place before. One farmer explained that this is because back then the elders were very strict and that stealing would not be accepted nor to take something unrightfully from someone else.

4.2. **Nature of agricultural support and its effects**

Since the 1990's government support, mainly through the Department of Agriculture, has favoured and propagated agricultural techniques and practices in line with the commercial/chemical model of agriculture, which other than including the use of machinery (such as mechanised ploughs, planters and harvesters) in the various stages of agricultural production for income, it also includes the use of chemicals (in the form of fertilizers, herbicides and pesticides) in farming, from soil preparation through to planting and harvesting. Furthermore, as of recent years, local farmers are being increasingly encouraged to use chemical fertilizers, herbicides and pesticides in food production for household consumption as well. Despite the high cost of this technology many farmers adhere to it.

While all male farmers reported on the success of chemical technology in local farming, two female farmers pointed to a fundamental consequence of the use of chemicals in farming – after the application of chemicals on a plot, farmers have to leave to field to recover for four years. The effect of this is that better-off farmers go around the community renting land for production, creating a constant demand for new land leading to an acceleration of soil degradation, which is fast becoming a common problem for farmers in the community. Also, one of the male farmers using chemical technologies mentioned that, "lately the soil needs more and more water", which a local community worker interviewed about this situation explained, "This is a sign of soil degradation".

One farmer stated that unfortunately chemicals were introduced in the absence of any kind of explanation of the consequences and side effects of their application, concluding that suppliers and distributors (government included) do not feel they have the responsibility to "explain these things".

One impact of this approach by government is the erosion of local farming knowledge. As exposed by one farmer in particular, in the past farmers would traditionally fertilize the soil with ash and sheep droppings, an ancient effective and sustainable organic technique. The current use of chemicals in farming means that this technique is fading out of use.. One farmer also linked the increase of use of chemicals in agriculture to the viability of organic farming practices in the community, stating that even if a farmer chooses not to use chemicals, pesticide and herbicide drift from neighbours have a negative impact on their own crop, forcing them to have to use chemicals on their crops as well. Another farmer explained that because its use underlies most governmental farming support and development initiatives, "if we don't take it, we get nothing."

One farmer also linked the increase of use of chemicals in agriculture to an increase in cases of cancer, asthma and other diseases in the community. According to her, "we had to tell them to use their chemicals only at night because they were spraying during the day, when the children that walk past the fields to go to school during the day. These chemicals are bad for the health and the minds of the children."

4.3. **Lack of maintenance of salinity ditches**

The issue of lack of maintenance refers specifically to channels that were built until the late 70s/early 80s on the edges of plots closest to the river which would absorb/drain the excess salinity of the soils (salinity ditches) in all plots close to the Olifants river (See Ebenhaeser Map in Annex 1). This effort was done in an effort to increase the amount of land available in the community for planting. This is no longer done nowadays. As explained by one of the interviewed community workers, this seems to be the main cause for the increase in salinity of the soil on the referred plots. Over time, this salinity is accumulated and starts affecting

more and more areas further away from the river. This means that 40% to 50% of the all plots close to the river (Nuweposs Noord, Nuwepos Suid, and a section of Olifantsdrif) have been damaged (see Ebenhaeser map in Annex 1). This problem would be solvable, as it is not a problem experienced by the farms on the other side of the river.

4.4. **Market access**

In terms of market linkages and output, as a result of limited market linkages, farmers are forced to sell their produce to resellers (shops and supermarkets in the village and in surrounding towns) at below-the-market prices, frequently pushing them into financial constraints.

There is no local entity or group effort to market the local production, and no active search for markets. The result is that buyers hear of availability of products by word of mouth. This is a problem specifically for lucerne production. The hope is that the lucerne producers cooperative might help in this respect.

As for the vegetables, local farmers have come to learn to plant for the market, in a bid to ensure the sale of their produce before it is planted. Marketing is a bit simpler because the volume of produce is not so big, and most buyers come through the community to buy the local produce.

Lack of market access and transportation of produce, especially for summer crops has also been mentioned as contributing to the precarious situation of farmers in the community.

4.5. **Gendered division of labour**

Although tending to animals is generally the task of the man of the house, tending for the animals kept at home (if any), as well as for the household food garden is mainly the responsibility of women. Household food gardens (for personal consumption) were common in the past, and maintaining them has traditionally been the role of women. Other than tending to the household chores, local women also engage in various handcraft activities like needlework and growing and selling small quantities of household crops to complement household income. However, the lack of start-up capital was pointed out as a main barrier for them to initiate such income-generation activities. Furthermore, respondents explained that given the extra burden of the added responsibilities in the household, most women in the community have no chance to attend to capacity building opportunities. Nonetheless, those who manage to attend these information sessions make an effort to share this information with local women.

4.6. **Community Cohesion and cooperation**

Most respondents pointed out that there is a great deal of conflict within the Ebenhaeser community and that lack of cooperation among farmers is a very strong characteristic of this community. One male farmer pointed out that, "farmers used to work together, cooperate and make sacrifices for each other. It's not like that anymore."

Although there was no clarity about when this "animosity" started, issues of community integration, cooperation and lack of initiative have been at the heart of various fundamental problems faced by this community. One of the most pressing issues is the finalization of the land claim process. The main reason for this is that according to regulation, the land has to be handed over to a community organisation which will then manage the process from there on.

This organisation would also be responsible for securing the funds required for the other related needs of farmers, i.e., farming implements and input needs. Despite many attempts no organisation of this nature has survived long enough to carry through this task. The groups that are formed are usually smaller "isolated" groups. This separation into smaller groups makes it that much more difficult to deal with problems at community level. As it stands, the land in which they are living is still held in trust by the Minister of Agriculture.

Furthermore, the imposed model of land enclosure clashed with old traditions, for example a problem relating to plot shapes which would often have some level of irregularity related to terrain contour lines and other agriculture-related factors. These clashes have over time created tensions among neighbours.

According to one government official, this lack of community cohesion is also evidenced by the fact that "most seminars and workshops are never more than 40% full". However, one female farmer explained that most women are too busy with household tasks to attend to training and capacity building opportunities. Respondents also reported that there have also been reports that power struggles in the community leadership and lack of integration of youth in decision-making have a negative effect in the upliftment of the community.

Respondents were unanimous in stating that these problems did not take place with such severity in the past. It would seem back then elders had much more of a sense of community, working together, cooperating and making sacrifices for each other, and were more concerned with helping those most in need. This is not evident in the community nowadays. As put by a male farmer "people don't care for one another. They only care for themselves or for those who are in their good books…" It was further pointed out that there aren't at the moment any community bodies to handle any of the community issues. Although such issues fall outside of the local municipality's jurisdiction and have to be dealt with at community level, as a

custodian of these communities, the local government wasfailing in assisting the formation of such structures.

5. CC AND ITS RELATION TO THE LIVELIHOODS AND LOCAL KNOWLEDGE OF SMALL-SCALE FARMERS OF THE EBENHAESER COMMUNITY

In line with Riché *et al.*'s (2009) statement on the matter, the livelihoods of the small-scale farmers such as those of the Ebenhaeser community are highly dependent on agriculture (farming and herding), and as such highly sensitive to CC. As such, and for organisation purposes, collected data under this sub-topic will be presented in relation to the main agricultural activities of local small-scale farmers, as well as the main characteristics of CC identified in section 2 of this chapter. Ultimately, the extent of the effects of CC on the livelihoods and ? of the small-scale farmers of the Ebenhaeser community serve as the indicator of their sensitivity to CC.

5.1.1. Mutual determinations of CC, Local Knowledge and Agricultural Production

shifts in season timing, Local Knowledge and Agricultural Production

Different effects of CC on local agricultural production were mentioned by respondents. Most farmers mentioned having to shift their planting times forward to fit the **shifts in season timing**. For example, vegetables (butternut, pumpkin, carrots, onions, sweet potatoes, potatoes) used to be planted in August and are now being planted in mid-October. This has a negative impact on income because farmers miss the December sales window, having their produce ready for the market only in January, when the market is already flooded and produce prices are low. In the case of bean farming, whereas in the past farmers would plant

in January, with some farmers planting as early as late December, nowadays they can only plant in February or not plant at all. This is because beans depend on the warmth of the summer months in its initial growth stages. This factor is aggravated by the fact that many local farmers plant beans for PANNAR and their contracts have a standard clause stipulating that beans must be planted by 15 October. During the first visit to the community (late September), one farmer explained that as this deadline comes closer, significant pressure is put on small-scale farmers as they have to make the hard decision about taking the risk of a loss in production (possibly incurring debt) or not planting at all and not having the income.

All farmers reported shifting the planting times of lucerne to fit changes in climate.

This shift in seasons has impacted on LK related to agricultural production, rendering accepted knowledge on seasonal climate conditions and characteristics becoming increasingly obsolete and inapplicable.

5.1.1.1. Unpredictability of climate, Local Knowledge and Agricultural Production

Unpredictability of climate has also been reported to have a strong negative impact on agricultural productivity. Farmers reported that where they used to have rain in April and May, in recent years they have been having mist, which causes rust (bean disease) with the potential to spoil a whole season's production. According to one respondent normally drier weather at this time of the year is used as a chance to harvest and bail lucerne (a process that usually takes a few days). As such, unexpected rains such as that which that fell in October (2012) can potentially destroy a whole harvest. This was indeed the case, in the 2012-13-season, where a second field trip surfaced that a large portion of the beans crop across Ebenhaeser had failed.

Unexpected rains in summer also have a more indirect, but just as significant an effect on lucerne production. Wet lucerne plants damage the bailing machine, which given its already poor maintenance levels is more likely to breakdown, having a cascading effect on all other farmers who depend on the use that piece of equipment. Furthermore, this unpredictability puts extra pressure on farmers as they can't be sure when to start preparing the fields for planting (normally 1 month prior to planting).

Also, whereas there used to be a "sorted summer and a sorted winter" and farmers knew the dates for starting to prepare the fields and plant produce nowadays the unpredictability of weather and shifts in season timing make this impossible. Moreover, irrigation water supply irregularities mean that farmers are even more dependent on rain water for production, making them even more vulnerable to the general reduction in rain quantities.

A second field trip revealed that, partly due to these problems the number of farmers risking planting 2013-season was reduced to no more than 40 individuals. from those involved in the community farm, and the larger-scale farmers of the community. Paradoxically, other than for home consumption, respondents explained that those who decided to plant were increasingly becoming less dependent on rain waters and more dependent on the irrigation water available.

These unprecendented changes in climate have compounded to reduce the relevance and applicability of certain portions of climate as well as environmental and gradually changing farming LK, as farmers become less dependent on the seasonality of rain waters.

5.1.1.2. Changes in rain patterns, Local Knowledge and Agricultural Production

Changes in rain patterns have been having a negative impact on at least one crop (beans), having the potential to destroy a whole harvest. The effects of such a possibility on the already cash-strapped small-scale farmers of the community can be even more severe given

that beans are one of the main cash crops in the community. This was just the case in the last season of (2013/13) when most of the bean harvest of the community was lost. These changes in rain patterns are having the effect of rendering LK on this aspect increasingly unreliable.

5.1.1.3. **Reduction in the amount of winter rains, Local Knowledge and Agricultural Production**

Additionally, a general **reduction in the amount of winter rains** has been linked to soil erosion and an increase in soil salinity levels on a number of plots, due to a decrease in the Olifants river water levels. This reduction in the amount of rain has also been reported to have a negative effect on the quality of produce, and by default on the income of local farmers.

At a deeper level, facing many water related problems in the past number of seasons, the effects of the reduction of rains in the community has been two-fold. While more than 50% of local farmers have decided not to risk planting this season, those who chose to plant, are becoming ever less reliant on rain water, being forced to adapt to the irregular and often insufficient irrigation water, dragging with it changes in the LK ?? about farming and climate.

5.1.1.4. Increased variability between hot and cold days, Local Knowledge and Agricultural Production

Increased variability between hot and cold days is also having a negative impact on the quality of vegetable (butternut, pumpkin, carrots, onions, sweet potatoes) production. This is certainly true in the case of beans, which need a specific soil temperature at certain growing

stages. For example, the ground has to be the right temperature during the first seven days after planting if germination is to be successful. As explained by local farmers, based on existing local knowledge on farming as well as on climate knowledge, beans are usually planted between September and October. However, this timing is clashing with current climate conditions forcing farmers to modify their practices. As such, while most farmers had already planted their beans, at least one farmer hadn't planted any yet because "temperature is not right yet." A follow-up field visit revealed that the vast majority of the bean production of the community had been lost. This impacted on LK related to agricultural production, again rendering accepted knowledge on the matter increasingly unreliable.

5.1.1.5. **Increase in frequency and intensity of cold and warm days, Local Knowledge and Agricultural Production**

Furthermore, a general **increase in frequency and intensity of cold and warm days** throughout the year has meant that at least about 20% of the vegetable growth period (3 months) has been either too hot or too cold during the past few years, having a negative impact on the quality of the produce, in turn affecting a farmer's income. Furthermore, in terms of its effects on local bodies of knowledge, these features of CC have meant that LK on this aspect has become increasingly unreliable.

5.1.1.6. **Increase in intensity and frequency of hot days and overall temperature increase, Local Knowledge and Agricultural Production**

Additionally, an **overall temperature increase,** and the **increase in intensity and frequency of hot days** in summer make it impossible for farmers to harvest and bail lucerne during the

day. Farmers counter this by working at night, often at a higher cost to them due to the use of hired labour and equipment. Although no specific impact of overall increase in temperatures on LK has been identified, such changes gradually reduce the reliability and relevance of LK on these aspects of climate.

5.1.1.7. **Reduction in the amount of winter rains, Local Knowledge and Agricultural Production**

Finally, a general **reduction in the amount of winter rains** has been linked to soil erosion and an increase in soil salinity levels on a number of plots, due to a decrease in the Olifants river water levels. This has made affected portions of land inappropriate for farming, meaning that affected farmers have to rely on other livelihood activities such as herding to maintain their livelihoods. Although no specific impact of general reduction in the amount of winter rains on LK has been identified, such changes gradually reduce the reliability and relevance of LK on these aspects of climate.

With regard to pests and pest management, all but one of the respondents mentioned an increase in the appearance of pests. Nonetheless, respondents could not clearly link this increase to CC. Although most respondents mentioned that one reason for this perceived increase is that in the old days farmers were not aware of some of the pests and their symptoms, one farmer was clear in stating that the people from the old days used to know how to deal with pests. One respondent mentioned that the fact that people do not have a planting programme, means they end up having pests on their plots that eventually spread to neighbouring plots. Nevertheless, all agreed that it was in the 80's, which was about the time when government started providing modern farmer support that the situation regarding pests

started to change. Nowadays, pest management and weed control are commonly carried out with the use of chemical pesticides and herbicides.

5.2. **Mutual determination of CC, Local Knowledge and Herding**

Although it seems that CC has no significant impact on livestock kept in the household environment, (usually in small numbers), this is not the case for the larger number of livestock kept in the grazing areas. Nevertheless, data collected has revealed that only two main features of CC are affecting the livestock production of local small-scale farmers – the shift in seasons' timing and the decrease in frequency and intensity of rains.

5.2.1. Shift in seasons' timing, Local Knowledge and Herding

Shifts in seasons' timing have also affected the ramming practices and procedures, which are timed to ensure a controlled lambing period, increasing the new-born lambs' chances of survival and thus the potential income of farmers, forcing farmers to delay the introduction of the rams (male sheep) into the ewe (female sheep) drove. Hence, whereas rams used to be introduced for mating in November, nowadays this only takes place at the end of December. This shift in season timing has impacted on LK related to livestock production by making accepted knowledge on ramming times unreliable.

5.2.2. **Decrease in frequency and intensity of rains, Local Knowledge and Herding**

The **decrease in frequency and intensity of rains** diminishes the abundance of nutrition available for grazers, having a negative impact on livestock production, as well as the environment. Although no specific impact of the decrease in frequency and intensity of rains

on LK has been identified, such changes gradually reduce the reliability and relevance of LK on these aspects of climate.

5.2.3. **CC and Household food gardening**

Despite its effects on income farming, and apart from the recent introduction of chemical packs for household use, no changes in the way household gardens are kept were mentioned. Two female farmer respondents also mentioned that no changes in household-grown medicinal plants (e.g. aloe vera) were noticed. The only change in household practices related to CC detected was that vegetables such as pumpkins, butternuts and the like did not keep for so long anymore, a change which was attributed to the perceived overall increase in temperature.

Apart from one farmer who said that increased changes in climate conditions "forced" farmers to communicate with each other and share experiences and knowledge in an effort to cope with such changes, no other respondents could confirm this, and all agreed that there was no formal or informal institution in the community promoting knowledge exchange around CC, its impacts on small-scale farming and ways to cope with and adapt to it.

In line with reviewed literature on the different features of CC, respondents were unanimous in pointing out the various climate-related hazards affecting their farming activities, and by default, their livelihoods. Table 6 (below) summarises the various impacts of CC on the livelihoods.

Table 6: CC and the livelihoods of small-scale farmers of Ebenhaeser

Climate Change	Impact on livelihood
Shift in seasons' timing	• Affects agricultural production of vegetables by causing potential losses of income due to contractual stipulations, or for missing prime market windows • Affects herding practices and livestock resources by endangering the survival of new-born calves (livestock)
Unpredictability of the seasonal weather	• Affects agricultural production through its potential to severely damage harvest (beans, and lucerne) • Potential to damage agricultural machinery • Affects agricultural production by putting extra pressure on farmers to take risks in "guessing" the right time to start preparing and plant fields
Changes in rain patterns	• Potential to severely damage the production of beans, one of the main cash crops in the community
Increase in frequency and intensity of cold and warm days	• Negative impact on agricultural production by affecting the quality of produce, reducing income of local small farmers
Reduction in the amount of winter rains	• Affects natural resources (farming land) through soil erosion and increased soil salinity levels on a number of plots, reducing income opportunities for farmers • Forces farmers to not farm • Pushes farmers into a stronger dependence on irrigation water • Impacts on natural resources (grazing land) by depleting nutrition available in grazing fields
Overall temperature increase	• Forces farmers to work (including hired labour) at unusual times, causing greater costs for working the fields

6. KEY LIVELIHOOD RESOURCES OF SMALL-SCALE FARMERS IN EBENHAESER AND RELATED IMPACTS OF CC

Having looked at the characteristics of the livelihoods of local small-scale farmers as well as their exposure to CC and the impact of CC on their main livelihood activities, the discussion can now move on to look at how CC is connected to the key livelihood resources of small-scale farmers in Ebenhaeser. This will give us an indication of the extent of the sensitivity of their livelihoods to CC.

6.1. **CC and local Natural Resources**

Small-scale farmers in Ebenhaeser observed significant negative impacts of CC on local **natural resources**, mostly so on local farm and grazing land and on rain water. According to one government official working in the community, there was an acceleration of soil degradation on a number of plots (mostly those closer to the floodplains adjacent to the river) caused by an increase in salinity and by soil erosion in recent (10 to 15) years. Other than the degradation of salinity draining infrastructures, this degradation of soils could be associated with a decrease in water volume in the Olifants River in recent years, a fact corroborated by at least one of the respondents.

Furthermore, all farmers reported on the reduction and changing of rain patterns and its impacts on farming and the grazing potential of grazing land. Overgrazing of the already limited grazing lands leads to a depletion of biodiversity, which not only reduces nutrition for livestock, but also forces animals to eat poisonous (some even deadly,) plants they would not feed on otherwise, potentially affecting the health of livestock, in turn affecting livelihoods of local small-farmers. Also, while the normal pattern is that most families in the community have a diversified livelihood base (farming, livestock, fishing), nowadays, CC, allied with other water related problems, has brought about a shift to dependency on livestock of up to 60% in the community. . This further aggravates the problem of overgrazing on the already overpopulated grazing areas.

Increases in overall temperature and in the frequency and intensity of hot days are also expected to increase water evaporation on farming and grazing land as well as in the irrigation canal.

Additionally, parcelling and sub-letting of plots, which is relatively commonplace in the community and used as a means to increase household income, means an increase in tenants,

which benefit from the landlords' water and grazing rights together with an overall increase in livestock numbers in the grazing areas. This increase in the total number of sheep increasingly poses the threat of degradation of grazing land by overgrazing. The Department of Agriculture has recently implemented a rotation programme in the grazing areas in an attempt to reduce degradation and preserve biodiversity.

6.2. **CC and local Physical Resources**

Few **physical resources** were mentioned to be affected by CC. Nonetheless, unpredictable rains did in more than one instance force farmers into situations in which they were compelled to use the local harvesting/bailing machinery inadequately (feeding wet lucerne into bailer), often damaging it. The lack of proper maintenance and repair means that this machinery can be inoperable for several days, having a negative impact on all other farmers who could potentially be using it.

6.3. **CC and local Human Resources**

CC is also affecting **human resources** that are important to farmers livelihoods. Added pressure is being put on their farming and herding skills as changing conditions increasingly render portions of their local farming, herding, environmental, and climate knowledge inapplicable, unreliable or obsolete, forcing them to "dig deeper" into their local knowledge bodies to find ways to cope with CC. Also, the increase in frequency and intensity of warm days as well as the overall increase in mean temperatures affected length of working hours of farmers, making farming a more strenuous activity.

6.4. **CC and local Social Resources**

In conjunction with, the various aforementioned features of CC in the Ebenhaeser community it could be expected that CC would have a negative impact on the productivity of the local women farmers group. CC was bound to have a negative impact on the availability of food for the community's poor. Furthermore, added pressures of CC mainly through changes in rain patterns and the overall reduction in rainfall reduce water availability were expected to exacerbate water related conflicts among local farmers, especially among those whose farms are connected to the local irrigation system.

6.5. **CC and local Financial Resources**

Finally, two of the most important financial resources of farmers being negatively affected by CC are their livestock and crops. CC features such as the reduction in the amount of winter rains, the unpredictability of the seasonal weather, changes in rain patterns, and increase in frequency and intensity of cold and warm days were reported to be having an increasingly real (and demonstrated) potential to severely damage the production and harvest of some of the main crops in the community, i.e. vegetables, beans, and lucerne, as well as having a negative impact on the quality of produce.

In terms of its impact on livestock, farmers indicated that the shift in seasons' timing, overall increase in temperature had the effect of endangering the survival of new-born lambs, potentially reducing this important income source. Table 7 below summarises this discussion, highlighting key resources directly impacted by CC in red. As we can see, the large majority of resources on which small-scale farmers of the Ebenhaeser community depend for their livelihoods seemed to be negatively affected by CC.

Table 7: Key local livelihood resource and related CC impacts

Livelihood Resources	Features of CC	Key Local Resources	Impact on Resource
Natural	• **Reduction in rainfall** • **Increase in frequency and intensity of cold and warm days** • **Overall increase in temperature**	Farmland Grazing fields Water sources	• Soil erosion and increased in soil salinity levels in a number of plots • Diminish the abundance of nutrition available in grazing fields • Increased evaporation on farming and grazing land, and on irrigation water
Physical	• **Unpredictable climate (unseasonal rains)**	Irrigation infrastructure Agricultural Mechanisation Centre	• Potential to damage agricultural machinery on which most depend
Human	• **Shift in seasons' timing** • **Unpredictability of the seasonal weather** • **Changes in rain patterns** • **Reduction in the amount of winter rains** • **Increase in frequency and intensity of cold and warm days** • **Overall increase in temperature**	Local farming knowledge Local herding knowledge Local climate knowledge Local ,environment knowledge Labour	• Renders portions of their bodies of local knowledge inapplicable, unreliable or obsolete • Extra pressure on local farmers farming and herding knowledge • Farmers forced to "dig deeper" into their local knowledge bodies • More straining working regime
Social	• **Shift in seasons' timing** • **Unpredictability of the seasonal weather** • **Changes in rain patterns** • **Reduction in the amount of winter rains** • **Increase in frequency and intensity of cold and warm days** • **Overall increase in temperature**	Women farmers group Local CBO's	• Negative impact on and reduction of overall agricultural production
Financial	• **Shift in seasons' timing** • **Reduction in the amount of winter rains** • **Unpredictability of the seasonal weather** • **Changes in rain patterns** • **Increase in frequency and intensity of cold**	Livestock Crops Agricultural Subsidies Pension	• Endangers the survival of new-born lambs • Severe damage to harvests • Negative impact on the quality of produce

	and warm days

Table 7 : Livelihood Resources adapted from Riché *et al*. 2009

7. CC HAZARDS AND RELATED COPING PRACTICES, AND LOCAL KNOWLEDGE USED

So far, the presented data is clear in depicting exposure and sensitivity to CC as well as its exacerbating effect on the already vulnerable conditions under which small-scale farmers in Ebenhaeser make their living. Nevertheless, in line with common views on the matter, the inherent adaptive capacity of small-scale farmers has meant that local farmers are already taking a series of steps based on their LK in an effort to reduce their vulnerability and cope with the added stresses of CC (David, 2009; Riché et al., 2009; Abeka, et al., 2012). As affirmed by a local small-scale farmer "[Climate is changing], so you have to change your practices."

7.1. **Shift in seasons' timing**

In order to cope with the impacts of the **shift in seasons' timing** on farming, local small-scale farmers have shifted planting times of their cash crops by one month to fit the changing climate conditions. For example, vegetables used to be planted in August and are now being planted in mid-October. This has a negative impact on income because farmers miss the December sales window, having their produce ready for the market only in January, when the market is already flooded and produce prices are low. In the case of bean farming, whereas in the past farmers would plant in January, with some farmers planting as early as late December, nowadays they can only plant in February or do not plant at all. This is because beans depend on the warmth of the summer months in their initial growth stages. All farmers

reported shifting the planting times of lucerne and potato to fit changes in climate. Also, in order to curb the impact of seasons' shifts on livestock production, many farmers are choosing to split the introduction of rams, too see how they fair and reduce risk of losses.

Although decisions on planting times were traditionally made based on the now increasingly unreliable understanding of local weather seasonality, farmers are now taking such decisions based on their broader knowledge and understanding of the local climate and environment, reading the weather and the local environment for signs of changing seasons which indicate appropriate conditions for planting. Farmers also make use of their local farming knowledge to gauge the right conditions for planting specific crops, i.e., beans. As explained by a local female farmer, "the warmth of the ground will tell you the right time to plant."

Shifts in seasons also impact on herding activities, particularly on the ramming season. To cope with this farmers have started experimenting with the ramming procedure, dividing the introduction of rams into "heats", separated by two weeks in between, in an effort to reduce risks posed by CC on the survival and prosperity of the flocks. Here again, farmers make use of their own, as well as designated herders' knowledge of climate and herding to inform such decisions.

7.2. **Unpredictability of seasonal weather**

The **unpredictability of seasonal weather** has also had a strong impact on local farming activities. As explained by one respondent, in order to cope with some of these impacts of this unpredictability, farmers evaluate the rain patterns and observe the surrounding environment for signs of changing seasons, using their environmental knowledge to guide their activities. Furthermore, farmers in the community are increasingly preparing their fields for sowing one to two months in advance in a bid to anticipate the rains. Also, at least one farmer mentioned

changes in crop choices to accommodate the changing conditions, stating that while in the old days farmers would plant "beans, carrots and cucumbers or even squash", he is now planting sweet potatoes at those times of the year. Here, local farmers make use of their extensive knowledge on local climate and environment conditions to read the conditions and decide on planting times and varieties. No coping practices aimed at mitigating the negative effects of the unpredictability of seasonal weather in relation to the lucerne were mentioned.

7.3. **Changes in rain patterns**

In responding to the **changes in rain patterns,** which had a substantial negative effect in at least one crop, local farmers are increasingly choosing to stop planting beans altogether, in an effort to reduce to risk of loss. One farmer also mentioned that he had been changing his choice of crops over time to fit the new conditions. This decision is based on local farmers' environmental knowledge coupled with their local agricultural knowledge, which informs them on the practicality and feasibility of planting crops such as beans in current climate conditions.

7.4. **General increase in frequency and intensity of cold and warm days**

A **general increase in frequency and intensity of cold and warm days** throughout the year has meant that at least about 20% of the vegetable (including beans) growth period (3 months) was either too hot or too cold for planting in the past few years. In an effort to curb the effects of this feature of CC in bean production farmers have been relying on their farming knowledge to manually monitor the ground temperature as well as on their climate knowledge to read and predict weather conditions and decide on the right time to plant.

7.5. **Overall temperature increase**

To cope with the **overall temperature increase** and its negative effects particularly on lucerne harvesting, farmers started working the fields at night (provided there is moonlight) when temperatures are cooler. This understanding was facilitated by the knowledge gathered over years of planting and harvesting the crop. Additionally, farmers started using more and more water on their fields to compensate for increased evaporation.

7.6. **General reduction in the amount of rainfall**

Last but not least, are the coping practices used by local farmers in an attempt to curb the negative effects of the **general reduction in the amount of rainfall**, particularly in winter, which increases soil erosion, in a number of plots in the community, as well as diminishing the availability of nutrition in grazing areas.

In relation to the former, farmers affected by soil erosion have been relying on the use of chemical fertilizer to compensate for this deficiency. Also, up to 60% of farmers in the community started shifting their income towards diversifying their livelihood sources by increasing their ownership and sales of livestock to compensate for losses.

As for the latter, farmers, using their knowledge of the local natural environment, gauged the availability of nutrition in the grazing areas based on the amount of rains in the previous year, planning ahead and planting and keeping extra feed for their livestock. Overall, as explained by one farmer, more and more farmers had to sell livestock during off-season (worse prices) to compensate for lack of income in agriculture.

Table 8 below summarises the efforts of small-scale farmers of the Ebenhaeser community to cope with CC. Additionally, using the logics base of Table 8, Table 9 identifies the various

bodies of LK used to guide the development of such coping practices. These tables illustrate the efforts of the small-scale farmers of the Ebenhaeser community to moderate and cope with the impacts of CC on their livelihoods, and indicate the degree of their adaptive capacity in relation to CC (IPCC, 2007).

Table 8: Climate Change and Agriculture-based Coping Practices

Climate Change	Coping practice
Shift in seasons' timing	• Shifting of planting times of all crops by one month • Changing of ramming technique (splitting the introduction of rams)
Unpredictability of the seasonal weather	• Preparing farming fields for planting up to 1 or 2 months in advance • Selling more sheep to compensate for reduction in income from agricultural production
Changes in rain patterns	• Gradually opting not to plant beans • Selling more sheep to compensate for reduction in income from agricultural production
Increase in frequency and intensity of cold and warm days	• Manually monitoring the ground temperature to decide on ideal planting time for beans • Selling more sheep to compensate for reduction in income from agricultural production
Reduction in the amount of rainfall	• Increased use of fertilizers to compensate for loss of soil fertility • Diversification of livelihood sources by owning and selling more sheep to compensate for loss of arable land • Planting and storing extra feed for livestock
Overall temperature increase	• Working the fields at night to escape high temperatures • Increasing watering of farming fields

Table 8

Table 9: Climate Change and Local Knowledge (LK) used

Climate Change	Local Knowledge used
Shift in seasons' timing	• Climate LK – farmers observed for the right weather conditions for planting their crops; • Environment LK – farmers observed the natural environment for signs of season changes; • Agricultural LK – knowledge of climate conditions necessary for planting of the various crop varieties (e.g. beans, lucerne); informed decisions on which crops to plant. • Herding knowledge – farmers decided to split introduction of rams in order to reduce risks
Unpredictability of the seasonal weather	• Climate LK – informed crop choices • Environment LK – farmers observed the natural environment for signs of season changes;

	• Agricultural LK – plan ahead and prepare the fields in advance; informed crop choices
Changes in rain patterns	• Climate LK – informed crop choices • Agricultural LK – informed crop choices
Increase in frequency and intensity of cold and warm days	• Climate LK – farmers observed for the right weather conditions for planting their crops; • Agricultural LK – gauging appropriate ground temperature for bean planting
Reduction in the amount of rainfall	• Environment LK – informs of the availability of feed for livestock in the following season • Agricultural LK – plan ahead and plant extra lucerne to feed livestock in the following season
Overall temperature increase	• Agricultural LK – knowledge of conditions necessary for lucerne harvesting

8. CHAPTER SUMMARY

This chapter was dedicated to the presentation of the data collected for this study. This data was presented in terms of the main analytical framework presented by the researcher in Chapter 2 depicting the dynamic process of the development of local knowledge-based CC coping practices by small-scale farmers (see Fig. 9).

As such, the presentation of data starts by outlining data collected in relation to the CC in the Ebenhaeser community as perceived by local small-scale farmers, which is followed by the data collected in relation to the key livelihood resources of local small-scale farmers, as well as that of other aspects of the Ebenhaeser community that are important for this study's problematic. The researcher then moved on to present data collected in terms of the impacts of CC on the aforementioned key livelihood resources.

Finally, the researcher presented the coping practices developed by local small-scale farmers to cope with the identified impacts of CC on their livelihoods, as well as the different bodies of knowledge used to inform such practices. The next chapter (Chapter 5) will present the analysis of this data.

CHAPTER 5

DATA ANALYSIS

1. INTRODUCTION

In order to reach this project's aim which is to investigate to what extent the Ebenhaeser community adapted the local knowledge and agriculture-based coping practices of small-scale farmers to cope with, and attempt to reduce, the vulnerability of their livelihoods to CC, one first needs to understand the vulnerability of their livelihoods in relation to CC.

, The theoretical framework developed by the researcher depicting the dynamic process of development of local knowledge-based CC coping practices by small-scale farmers (see Fig. 9 in Chapter 2) formed the main basis for this analysis. In the same vein Riché *et al.*'s (2009) CC vulnerability framework (see Table 1 in Chapter 2) was used to facilitate a better understanding of the vulnerability of the livelihoods of small-scale farmers in Ebenhaeser to CC. This framework also helped to understand collected data in terms of CC exposure and sensitivity, and the use of local knowledge by small-scale farmers to develop CC coping practices as a manifestation of their adaptive capacities in the face of the various CC-related hazards identified by local farmers.

Furthermore, as illustrated in the main conceptual framework (see Fig. 9 in Chapter 2), and based on Killian *et al.*(2006), Midgley *et al.*(2005), and Gbetibouo and Ringler's (2009) views on this matter, this analysis centres on the understanding of the intensity of the CC exposure and sensitivity. Both sources, the framework (Fig. 9) and the abovementioned authors further highlight the extent to which the adaptive capacity (and CC coping practices)

of the small-scale farmers of Ebenhaeser in mitigating the vulnerability of their livelihoods in relation to CC are mediated by the local underlying drivers of vulnerability.

Ultimately, this process lays the foundation for the analysis of collected data in an attempt to reach a deeper insight into the dynamic process of development of these CC coping practices by local small-scale farmers of the Ebenhaeser community, and how sustainable and effective their efforts have been in doing so.

To facilitate the understanding of this dynamic process, data was analysed by breaking the process up into smaller "chunks", allowing the researcher to look at and analyse different components of the process and their interactions in a more focussed manner. As such, the analysis will start by analysing the exposure and sensitivity of the key livelihood resources of local small-scale farmers to CC, and how these interact with the abovementioned underlying drivers of vulnerability.

The second half of this analysis focusses on the adaptive capacity of local small-scale farmers and how their CC coping practices, including the local knowledge used interact with the underlying drivers of vulnerability to mitigate the vulnerability of the livelihoods of these farmers in relation to CC.

Finally, this analysis reveals the level of vulnerability of the key livelihood resources, and by definition the livelihoods of local small-scale farmers to CC. The outcome of this analysis will set the stage for understanding the effectiveness and sustainability of the various coping practices developed by local small-scale farmers in their effort to mitigate the impact of, as well as reducing, the vulnerability of the livelihoods of local farmers to CC.

2. THE EXPOSURE AND SENSITIVITY OF THE LIVELIHOODS OF LOCAL SMALL-SCALE FARMERS TO CC

According to Gbetibouo and Ringler (2009), exposure of key livelihood resources to CC is one of two main elements vital to the identification of the impact of CC on the small-scale farmers such as those of the Ebenhaeser community. The second, and according to Riché *et al.,* (2009) inseparable element of this impact, is the sensitivity of the livelihoods of these farmers to CC (Gbetibouo and Ringler, 2009). Respecting the interdependence between these two elements, the researcher opted to perform their analysis in conjunction with each other.

The data collected for this study was clear in revealing that, in line with reviewed literature on the different features of CC (Twomlow *et al*. ,2008; David, 2009), respondents were unanimous in pointing out the various climate-related hazards affecting their farming activities, and by default, their livelihoods (see Table 3). These features, which are viewed within this study as constituting their **exposure to CC** (see Table 4), are determined by the magnitude, character and rate of CC in the Ebenhaeser community (Riché et al., 2009) The features also interact with the local underlying drivers of vulnerability, to impact on their key livelihood resources (see Table 6), which is seen here as their **sensitivity to CC**. Additionally, these elements of CC exposure and sensitivity are mediated by a series of local underlying drivers of vulnerability (Killian *et al*, 2006; Midgley *et al.*, 2005; Gbetibouo and Ringler, 2009), outlined in section 4 of the data presentation chapter (chapter 4), the CC related hazards in the Ebenhaeser community are subdivided into the following categories: a shift in seasons' timing, unpredictability of the seasonal weather, changes in rain patterns, an increase in frequency and intensity of cold and warm days, reduction in the amount of winter rains, and an overall temperature increase.

2.1. **Shifts in season timing**

A **shift in seasons' timing** was the first element of exposure identified by most respondents. Here, the one month delay in the summer and winter planting seasons forced farmers to delay planting in both seasons by a month. In terms of their sensitivity to CC, this hazard had a negative impact on income from sales of agricultural production (financial resource), causing farmers to miss the prime sales window, and forcing them to sell their produce at lower prices. Additionally, in terms of bean production, changes caused by this shift in season timing clashed with contractual obligations (financial resource), putting small-scale farmers in a position where they had to take the hard decision of taking the risk of loss in production (possibly incurring debt) or not planting at all and not having the income.

In relation to livestock production, the **shifts in seasons' timing** also affected the ramming practices and procedures, forcing farmers to delay ramming procedures by one month.

As far as the impact of this feature of CC on the local bodies of knowledge goes, while rendering portions of it obsolete or inapplicable (human resource), specifically in relation to climate the fact that farmers picked up on this change and managed to adapt to it shows the adaptability of their local farming and herding knowledge.

2.2. **Unpredictability of climate**

Local farmers also reported that the **unpredictability of climate** was having a strong negative impact on agricultural productivity. The unexpected changes in climate conditions, as with the case of mists replacing typical rains in April and May, were causing crop diseases (such as rust in beans) with a proven potential to spoil a whole seasons' production (financial resource), forcing farmers to increasingly abstain from planting the crop. Also, unseasonal

rains considerably increased the potential to destroy whole lucerne harvests, at great risk to farmers. The negative impact of unseasonal rains on the farming activities of the small-scale farmers of the Ebenhaeser community was further exacerbated by the degradation and damage to farming machinery caused by improper use delaying or even preventing harvesting and bailing the crop. , This delay had wider consequences involving other local farmers given their dependence on these scarce resources (social resource).

Additionally, the unpredictability of climate made timing of preparation of farming land for planting almost impossible (financial resource). This unpredictability also caused farmers to increase their reliance on the already deficient irrigation water supply to keep up the production cycles. Compounded by irregularities in irrigation water supply linked to the deteriorating conditions of the canals, internal conflict in the community, as well as the changes in rain patterns and the overall reduction in rainfall, made farmers ever more sensitive to the effects of CC, in particular those whose access to water resources is more limited, such as the farmers whose plots are located further down the irrigation canal, or the women farmer group, who does not have access to irrigation water at all.

The impact of unpredictability of seasonal weather on LK is evidenced by the limited range of solutions local small-farmers devised to deal with this feature. As such, it has had the effect of rendering accepted knowledge on seasonal climate conditions and characteristics as well as appropriate farming practices increasingly unreliable, if not inapplicable (human resource).

2.3. Changes in rain patterns

Changes in rain patterns, was one of the hazards that was most mentioned by local farmers. According to them this came in the form of a great variability in rain volumes for equivalent periods in recent years, something that had never been witnessed before. Also, to the detriment of local farmers, patterns of winter rains have changed in character and intensity (natural resource).

Another characteristic of this hazard has been the recent changes in spatial rainfall patterns and climate conditions increasingly occurring across the community. Again, something like this had never been witnessed before.

These changes in rainfall also increased the reliance of local farmers on irrigation water to keep up the production cycles. Again, compounded by irregularities in irrigation water supply linked to the deteriorating conditions of the canals and internal conflict in the community, as well as by the unpredictability of climate and the overall reduction in rainfall, this feature of CC makes farmers ever more sensitive to it. Additionally, for those whose access to water resources was more limited, such as the farmers whose plots are located further down the irrigation canal, or the women farmer group, who did not have access to irrigation water at all, this feature of CC is expected to have an even more severe impact.

Farmers reported that these changes had a negative impact on at least one crop (beans), potentially destroying a whole harvest (financial resource). The effects of such a possibility greatly increased the sensitivity of the already cash-strapped small-scale farmers of the community, given that beans are one of the main cash crops in the community. These changes in rain patterns are having the effect of rendering LK on climate as well as agricultural LK linked to those features increasingly unreliable (social resource).

2.4. **Reduction in rainfall and decrease in frequency and intensity of rains**

A **reduction in rainfall** was also identified by respondents as a CC hazard to which they were exposed, noting that there had been a significant reduction in the amount of rains in the previous four years. This reduction in rainfall has an important effect on the sensitivity of local farmers to CC. The limited and defective supply of irrigation water linked to the deteriorating condition of the canals as well as uneven water distribution and internal conflict in the community, in addition to the unpredictability of climate and the changes in rainfall patterns, further reduce the availability of water for farming activities (natural resource).

This reduction in rainfall makes farmers even more sensitive to CC. Farmers also reported that it had a negative effect on the quality of produce, and by default on the income of local farmers (financial resource). Evidence to this negative effect was the almost spectacular failure of the women project's cabbage sales, where along with missing the market window, the poor quality of the produce resulted in at least 70% loss in income.

Finally, this reduction in rainfall has also been linked to a decrease in the water levels of the Olifants River, causing soil erosion and contributing to the increase in soil salinity levels on a number of plots, thus limiting the amount of land available for farming (natural resource). As mentioned above, the effect of this feature of CC is further amplified within the livelihoods of those farmers whose access to water resources is more limited, such as the farmers located further down the irrigation canal, or the women farmer group, who does not have access to irrigation water at all, and are even more limited in the possibility of drawing water for their fields from the river.

As a subset of the overall reduction in rainfall, the **decrease in frequency and intensity of rains** has the effect of diminishing the abundance of nutrition available for grazers (natural resource). It also has a negative impact on livestock production, as well as the environment,

thus further increasing the sensitivity of their livelihoods to CC. The limited availability of land for grazing along with the recent trend of increased livestock numbers exacerbates the sensitivity of local small-scale farmers to CC.

Although no specific impact of general reduction in the amount of winter rains on LK has been identified, such changes gradually reduce the reliability of climate LK on this aspect, as well as the relevance of agricultural LK linked to such changes.

2.5. **Increased variability between hot and cold days**

Local farmers have also been exposed to an **increased variability between hot and cold days**. This feature of CC has had a negative impact on the quality of vegetable and beans production (financial resources). This increase in variability of hot and cold days had a negative effect in at least 20% of the vegetable growth period, it being a strong factor in increasing the sensitivity of local farmers to CC.

In terms of its effects on local bodies of knowledge, these features of CC have made portions of farming as well as climate LK increasingly unreliable. The unpredictability of such events also makes it difficult for the existing bodies of knowledge of local farmers to be "updated" in a meaningful manner.

2.6. **Overall temperature increase**

Finally, the last element of CC exposure mentioned by small-scale farmers in the Ebenhaeser community was the **overall temperature increase**, which made it impossible for farmers to harvest and bail lucerne during the day in summer (human resource). Although no specific

impact of overall increase in temperatures on LK has been identified, such changes gradually reduce the reliability and relevance of LK on these aspects of climate and farming.

Overall, although respondents could not clearly link this increase to CC, the increase in pests can be seen as a consequence of overall CC in the community. Nevertheless, despite disagreement on this issue, all respondents agreed that it was in the 80's, which was about the time when government started providing modern farmer support that the situation regarding pests started to change.

Furthermore, as local farmers in the community use increasing larger amounts of chemical pesticides to deal with this issue as well as the general use of chemical fertilizer, the larger quantities of these chemicals on their fields has the effect of increasing soil degradation. As evidenced by respondents, local farmers resort to applying more chemical fertilizers in an attempt to reduce soil degradation and improve fertility, which ultimately, as explained by Shebby (2010), leads to more soil degradation. This vicious cycle further damages the local natural resources, increasing the vulnerability of local farmers' livelihoods in general, and in relation to CC in particular.

Table 10 below presents a summary of exposure and sensitivity of the small-scale farmers of the Ebenhaeser community to CC, including the underlying drivers of vulnerability which influence them.

Table 10: CC Exposure and Sensitivity of the Small-scale Farmers of the Ebenhaeser community

Exposure		Sensitivity			
Climate Change	**Underlying Drivers of Vulnerability**	**Impact on Local knowledge**		**Impact on Key Livelihood Resources**	**Impact on livelihood**
Shift in seasons' timing	• 1 month delay in the summer planting seasons, from mid-August, to mid-September. • 1 month delay in the winter planting season shifting from mid-April to mid-May.	Soil degradation due to chemical use	Increasingly renders climate as well as related agricultural and herding knowledge obsolete	• Financial Resource – Agricultural • Human Resource – Local Knowledge (climate, farming, herding)	
Unpredictability of the seasonal weather	• Unpredictable off-season rains • Unpredictable fluctuations in monthly rain volumes • Difficulty in distinguishing between seasons	Irregularities in irrigation water supply linked to the deteriorating conditions of the canals, uneven water distribution, and internal conflict in the community. Soil degradation due to chemical use	Renders LK on seasonal climate conditions and characteristics as well as related farming LK increasingly inapplicable	• Financial Resource – Agricultural Production • Natural Resource – Water source • Social Resource – Agricultural machinery • Human Resource – Local Knowledge (climate and farming)	
Changes in rain patterns	• Changes in patterns of winter rains • Changes in spatial rainfall patterns and climatic conditions across community	Irregularities in irrigation water supply linked to the deteriorating	Renders LK on climate and farming increasingly	• Financial Resource – Agricultural Production • Social Resource – Agricultural machinery • Natural Resource – Water source • Human Resource –	

		conditions of the canals as well as internal conflict in the community Soil degradation due to chemical fertiliser use	unreliable	Local Knowledge (climate and farming)
Reduction in Rainfall	• Substantial reduction of winter rains • Decrease in frequency and intensity of rains	Irregularities in irrigation water supply linked to the deteriorating conditions of the canals as well as internal conflict in the community; Limited grazing land Soil degradation due to chemical use	Gradual reduction of the reliability and relevance of LK on these aspects of climate.	• Natural Resource – Water source, farming land, grazing land • Financial Resource – Agricultural Production • Human Resource – Local Knowledge
Increase in frequency and intensity of cold and warm days	• Cold days are becoming colder • More frequent and intense variations in temperature	Soil degradation due to chemical use	Renders farming and climate LK on this aspect increasingly unreliable	• Financial Resource – Agricultural Production
Overall temperature increase	• Weather is getting warmer and warmer	Soil degradation due to chemical use	Gradual reduction of the reliability and relevance of LK on these aspects of climate.	• Human Resource – Labour, Local Knowledge (farming and climate)

3. THE ADAPTIVE CAPACITY OF LOCAL SMALL-SCALE FARMERS IN EBENHAESER TO CC

Despite the multifaceted challenges posed by the threats of CC and its exacerbating effect on the already vulnerable conditions under which small-scale farmers in Ebenhaeser make their living, the inherent adaptive capacity of small-scale farmers (Laube *et* al., 2011; Twomlow *et al.*2008) has meant that local farmers are already making a series of efforts to reduce their vulnerability and cope with the added stresses of CC. As explained by Gbetibouo and Ringler (2009), these efforts are materialized in the form of the coping practices developed by local farmers to cope with and mitigate the adverse effects of CC on their livelihoods.

Data findings have shown that in response to the various features of CC (CC hazards), mediated by the local underlying drivers of vulnerability, local farmers have developed and applied a range of coping practices aimed at reducing the vulnerability of their livelihoods to CC, making use of their local bodies of knowledge to do so.

3.1. **Shift in seasons' timing**

In response to the **shift in seasons' timing**, apart from changes in ramming practices, local small-scale farmers shifted planting times of their income crops by one month. This coping practice was developed making use of their broader knowledge and understanding of the local climate and environment, reading the weather and the local environment for signs of changing seasons which would indicate appropriate conditions for planting.

Nevertheless, although this coping practice has been successful in adapting to this specific feature of CC, this shift in planting times caused local small-scale farmers to miss out on prime marketing windows, with their produce reaching the market late, when the market is

already flooded, dampening its effectiveness in reducing the overall vulnerability of these farmers' livelihoods to CC.

3.2. **Unpredictability of the seasonal weather**

The **unpredictability of the seasonal weather** also had a strong impact on local farming activities. In this case, although not much could be done to reduce the unpredictability, local farmers adapted by preparing their fields up to one month in advance, making use of their extensive knowledge on local climate and environment conditions, as well as that of farming, in order to plan ahead, and to read the conditions to seize the opportunity to plant when the time and conditions are right. Nevertheless, this coping practice cannot guarantee any successes, as once planted there is no guarantee that the weather might not suddenly change and damage production, sometimes beyond repair, as was the case with the beans production of the women's project in the last season (2013).

Furthermore, although local farmers also resorted to selling more livestock to complement household income during times of shortage, the fact that they had to sell more and more of their livestock in low-demand seasons, means they end up losing money of the sales, to their own detriment. Additionally, limits on livestock ownership imposed by government limited the amount of income generated through this practice. Farmers nevertheless started relying increasingly on livestock ownership, which given the limited grazing areas available for the community, could not be accepted as a sustainable practice.

3.3. **Changes in rain patterns**

In responding to the **changes in rain patterns** local environmental knowledge coupled with local agricultural knowledge did not only guide the manual monitoring of optimum planting conditions and informing about planting times, but also served as the basis for local small-scale farmers' decision to change their crop choices. Unfortunately, compounded by the unpredictability of climate and deficient water supply, the success of this practice was limited, as evidenced by the performance of beans and cabbage production in the women's project.

Here again, local farmers also resorted to selling more livestock to complement household income during times of shortage. However, the success of this coping practice was equally dampened by the fact that farmers ended up losing money in the off-season livestock sales. Additionally, limits on livestock ownership imposed by government limited the amount of income generated through this practice. Given the limited grazing areas available for the community, the increased reliance on livestock ownership was not a sustainable CC coping practice.

3.4. **General increase in frequency and intensity of cold and warm days**

The same coping practices were used to cope with the **general increase in frequency and intensity of cold and warm days.**, In this instance local environmental knowledge coupled with local agricultural knowledge not only guided the manual monitoring of optimum planting conditions and decision-making on when and what to plant, but for that matter, if anything should be planted at all.

Additionally, local farmers compensated for the lack of income from farming activities by selling more livestock. Again, the success of this coping practice had been dampened not only by the fact that they in selling their livestock in low-demand seasons they ended up losing money on the exchange, but also by the restrictions put by government on the quantity of livestock allowed to be owned by local farmers, which further limits the amount of income they can generate from this practice. Owning more livestock than the grazing areas can handle made this an unsustainable practice.

3.5. **Reduction in the amount of rainfall**

In other cases, such as in their in attempt to curb the negative effects of the **general reduction in the amount of winter rains,** local farmers used their agricultural knowledge as well as their understanding of the local climate and environment as basis for their livestock management planning, using their foresight to plant and store extra feed for their livestock, in preparation for predicted shortages in grazing land.

In other words, local farmers coped with this hazard by diversifying their livelihood sources, increasing their ownership and sales of livestock to compensate for losses and lack of income in agriculture. Again, this coping practice was imited in its effectiveness by the limited amount of land available for grazing, as well as the cap on livestock ownership imposed by government. This coping practice also leads to overgrazing, which not only depletes the natural environment, stalling the various natural life-cycles, but also forces animals to feed on poisonous species which they would not normally eat, with negative effects on their health.

Additionally, local farmers mentioned resorting to the use of chemical fertilizers to cope with the loss of soil fertility on their plots, which further entrenches the vicious cycle of soil degradation and dependency on chemical inputs (Shebby, 2010).

Finally, compounded by the deficiencies in water supply, and almost total lack of access to water by some local farmers, at least 50% of farmers in the community opted out of farming during the (2012/13) season, rather focusing either on livestock or searching for work on the large-scale farms in the surrounding areas.

3.6. **Overall increase in temperature**

Last but not least, in a bid to cope with the **overall increase in temperature**, informed by their extensive agricultural knowledge and despite the increase in cost, farmers shifted their working hours to fit the requirements of their crops, and resorted to increasing the amount of water used in irrigation of farming land.

However, while the former practice increases the strain of farm work on the lives of local farmers, the success of the latter in reducing the vulnerability of their livelihoods to CC is significantly limited by all the problems mentioned above in connection with water supply and strife in the community as well as the CC threat.

While most of the coping practices being used could be seen as suitable and appropriate long-term coping practices, there are some current coping practices, which are not efficient or appropriate for long-term adaptation. Such is the case of the practice of increasing ownership and sales of livestock to compensate for losses as a means of diversifying livelihood sources. Similar to the case of coal and firewood selling in the Somali and Borana communities of Ethiopia (Riché *et al*., 2009), this practice is not sustainable.

The practice of increasing watering of fields to counter increase evaporation due to overall temperature increases, which, given the fixed amount of irrigation water allocated to the community, will inevitably exacerbate the unequal distribution of irrigation water, by benefiting some to the detriment of most small-scale farmers in the community.

A large number of local farmers were also reported to decide not to plant this season, in a bid curtail the risk of financial loss. While some of them can fall back on government pension (elders) others opted to seek for waged-work in surrounding large-scale farms. While this practice might give some stability to individuals, they are not sustainable at a community level, since it results in the downfall of agriculture – the economic and cultural backbone of the community – in Ebenhaeser. Because they could not be linked to any climate hazard in particular, these coping options are featured as a possible coping strategy for all categories in summary table below.

Table 11 below summarizes the coping practices developed by the small-scale farmers of the Ebenhaeser community, including the LK used to achieve them and the underlying drivers of vulnerability which limit the adaptive capacity of local farmers in relation to each of the coping practices developed, as well as highlighting in red those coping practices which are seen as not being effective in reducing the vulnerability of local small-scale farmers to CC.

Table 11: Climate Change, Agriculture-based Coping Practices and Local Knowledge (LK) used

Climate Change		Coping practice	Local Knowledge used	Underlying Drivers of Vulnerability
Shift in seasons' timing	• 1 month delay in the summer planting seasons, from mid-August, to mid-September. • 1 month delay in the winter planting season shifting from mid-April to mid-May.	• Shifting of planting times of all crops by one month • Changing of ramming technique (splitting the introduction of rams) • Procuring waged-work • Falling back on government assistance (pensions)		• Climate LK – farmers observed for the right weather conditions for planting their crops; • Environment LK – farmers observed the natural environment for signs of season changes; • Agricultural LK – knowledge of climate conditions necessary for planting of the various crop varieties (eg. beans, lucerne); informed decisions on which crops to plant. • Herding knowledge – farmers decided to split introduction of rams in order to reduce risks
Unpredictability of the seasonal weather	• Unpredictable off-season rains • Unpredictable fluctuations in monthly rain volumes • Difficulty in distinguishing between seasons	• Preparing farming fields for planting up to 1 or 2 months in advance • Increasing ownership and sale of livestock (sheep) to compensate for reduction in income from agricultural production • Procuring waged-work • Falling back on government assistance (pensions)		• Climate LK – informed crop choices • Environment LK – farmers observed the natural environment for signs of season changes; • Agricultural LK – plan ahead and prepare the fields in advance; informed crop choices
Changes in rain patterns	• Changes in patterns of winter rains • Changes in spatial rainfall patterns and climatic conditions across community	• Gradually opting to not plant certain crop varieties • Increasing ownership and sale of livestock (sheep) to compensate for reduction in income from agricultural production • Procuring waged-work • Falling back on government assistance (pensions)		• Climate LK – informed crop choices • Agricultural LK – informed crop choices
Increase in frequency and intensity		• Manually monitoring the ground temperature to		• Climate LK – farmers observed for

of cold and warm days	• Cold days are becoming colder • More frequent and intense variations in temperature	decide on ideal planting time for beans • Increasing ownership and sale of livestock (sheep) to compensate for reduction in income from agricultural production • Procuring waged-work • Falling back on government assistance (pensions)	the right weather conditions for planting their crops; • Agricultural LK – gauging appropriate ground temperature for bean planting
Reduction in the amount of rainfall	• • Substantial reduction of winter rains • Decrease in frequency and intensity of rains	• Diversification of livelihood sources by owning and selling more sheep to compensate for loss of arable land • Planting and storing extra feed for livestock • Increased reliance on chemical fertilizers • Procuring waged-work • Falling back on government assistance (pensions)	• Environment LK – informs of the availability of feed for livestock in the following season • Agricultural LK – plan ahead and plant extra lucerne to feed livestock in the following season
Overall temperature increase	• Weather is getting warmer and warmer	• Working the fields at night to escape high temperatures • Increasing watering of farming fields • Procuring waged-work • Falling back on government assistance (pensions)	• Agricultural LK – knowledge of conditions necessary for lucerne harvesting

4. CHAPTER CONCLUSION

Making use of both the analysis frameworks presented in the literature review chapter of this study, as well as thematic ordering and systematization methods, the researcher was able to analyse components of the vulnerability – CC exposure, CC sensitivity, and adaptive capacity – of the small-scale farmers of the Ebenhaeser community, and their interactions in a more focussed manner, with the goal of facilitating a clear view of the dynamic process of development of CC coping practices by these small-scale farmers. of Among the first aspects revealed by this analysis is the significant impact of CC on their livelihoods, due to their dependence on climate sensitive sectors, i.e., agriculture (and herding to a smaller extent). Research participants consulted in the community have been observing climate trends that are consistent with scientific climate change observations and projections, including a shift in seasons' timing, the unpredictability of the seasonal weather, changes in rain patterns and reduction in rainfall, an increased frequency and intensity of cold and warm days, and an overall temperature increase. These trends are expected to continue in the future, and as predicted, will have a significant effect on the key livelihood resources on which local farmers in Ebenhaeser depend These trends are especially important as resources of farmers who are unfortunate in their current positioning in relation to the irrigation system, or of those, such as the women farmer group, who do not have any access to irrigation water.

Other than their direct impact on the key livelihood resources, as well as the local knowledge and farming activities of local small-scale farmers, the identified features of CC interact with local underlying drivers of vulnerability, such as the deficient and uneven water supply and market access issues, community conflict issues, and the nature of agricultural support. Further limiting issues are not only related to the community's historical context (unequal access to land and land usage policies,); but also increase the sensitivity of their livelihoods

due to the CC threat, and limit their adaptive capacity in general, and in relation to CC in particular.

In line with reviewed literature, the vast majority of farmers' CC coping practices were based on the existing bodies of local knowledge, and the fact that most coping practices involved changes to agricultural practices. Nevertheless, while local small-scale farmers identified a range of coping practices to cope with the negative effects of CC, the effectiveness of these coping practices in reducing the vulnerability of their livelihoods to CC was constricted by their interactions with the identified underlying drivers of vulnerability (see Table 11). Also, this analysis revealed some coping practices developed by these farmers which actually increased their vulnerability to CC.

To sum up**,** he results of this analysis revealed the significant extent of the vulnerability of the livelihoods of the small-scale farmers of the Ebenhaeser community to CC. Additionally the results also revealed the extent of the effectiveness of the range of coping practices developed by these farmers in reducing their vulnerability to CC, contributing to the overall aim of this study.

In the following chapter (Findings and Conclusions) the researcher will present his main findings and conclusions arising from this study.

CHAPTER 6

RESEARCH FINDINGS AND CONCLUSIONS

1. INTRODUCTION

The main aim of this research project was to investigate how small-scale farmers of the Ebenhaeser community's local knowledge and agriculture-based coping practices are adapted to deal with and attempt to reduce the vulnerability of their livelihoods to CC.

This goal was achieved by conducting an analysis of the vulnerability of livelihoods of these farmers to CC with a view to analyse the dynamics of the process of development of local knowledge-based coping practices of small-scale farmers of the Ebenhaeser community aimed at reducing the vulnerability of their livelihoods to CC. This analysis aimed at investigating and illustrating the impact of CC on the livelihoods and local knowledge of small-scale farmers of the Ebenhaeser community, and revealing what agriculture-based CC coping practices have been developed by them to cope with these impacts, as well as their effectiveness in doing so.

The exploratory case study research format used in this study enabled the researcher to perform a detailed contextual analysis of the various elements affecting the dynamics of the impact of CC in Ebenhaeser, and their relationships. It also allowed the researcher to closely examine the data within the local context of the Ebenhaeser community, allowing for an illustration of the realities of the livelihoods of local small-scale farmers in the face of CC and how they respond tothem.

Data was collected using in-depth individual interviews, semi-structured interviews, and special focus group discussions with local stakeholders with the aim of capturing a deeper understanding of the physical and historical context in which the Ebenhaeser community is inserted, as well as providing and attaining a clear insight on the impacts of climate change on local farming and how farmers have adapted to the changing conditions and added pressures of CC.

2. RESEARCH FINDINGS

2.1. CC and its impact on the livelihoods of the small-scale farmers of the Ebenhaeser community

In line with reviewed literature, small-scale farmers of the Ebenhaeser community have been unanimous in pointing to the existence and the various features of CC in their community, as well as the impact of CC on their farming activities. According to them these features include a shift in seasons' timing, the unpredictability of the seasonal weather, changes in rain patterns, a general increase in frequency and intensity of cold and warm days, an overall temperature increase and a general reduction in the amount of winter rains. All of these features, albeit in different forms and degrees, have had a significant impact on various key livelihood resources on which local farmers depend, ultimately having a significant effect on their livelihoods. Also important is the impact of CC on local herding, which, while not being the farmers' main occupation or even source of income, is a local tradition and has always been an additional and important alternative source of livelihood for them, more so in current times. These features of CC also interact with other underlying drivers of vulnerability which in many instances exacerbate the exposure and sensitivity of their livelihoods to CC.

Furthermore, CC has also had a significant impact on the current existing local knowledge bodies used in the day-to-day activities of local farmers.

While managing to develop a series of coping practices, the local bodies of knowledge (agro-ecological modes of production, soil and pest management,) of local small-scale farmers have been gradually eroded due to the nature and extent of governmental agricultural policies (agro-chemical model). Compounding this situation, CC has had the effect of rendering certain portions of the local knowledge bodies (mostly relating to the environment) which were seen as fundamental to their farming activities (such as season timings and weather characteristics) increasingly unreliable or even obsolete. This has had the effect of further reducing CC coping options, aggravating their adaptive capacity.

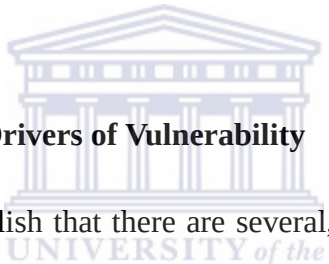
While the various identified features of CC and their interactions with the underlying drivers of local vulnerability indicate their level of exposure to CC, the extent of the impact of these various CC effects on the key livelihood resources of local small-scale farmers portrays their CC sensitivity. In this sense, the data analysis exercise revealed the significant level of sensitivity of these farmers to CC, evidenced by the extent of the impact of the different features of CC on the key local livelihood resources, including the bodies of local knowledge used by local small-scale farmers in their farming. In conjunction, the CC exposure and sensitivity of these farmers illustrated the overall impact of CC on the livelihoods of the small-scale farmers of the Ebenhaeser community.

This study has also revealed that the level of impact of CC on local small-scale farmers varies according to spatial disposition of the farms in question (i.e. position in relation to the irrigation system, proximity to the Olifants River). Additionally, despite the nature and size of this study not allowing for a detailed analysis of the prevalent gender relations in the Ebenhaeser community and their interactions with their sensitivity to CC and adaptive

capacity, the researcher was able to uncover sufficient evidence to reasonably state that the differing roles of women (often unfair, and overbearing on women) in farming and in the household, as well as their unequal access to resources are important factors in the differentiated way in which CC affects women farmers in the community.

The same applies to CC's impact on local young farmers, where evidence suggests that given generational divisions and relationships seem to restrict the access of youth to land and their engagement in agriculture.

One can infer from this that t local male and female, as well as youth and adult small-scale farmers in Ebenhaeser are impacted by and cope with CC in differentiated ways.



2.2. **CC and Local Underlying Drivers of Vulnerability**

This study was also able to establish that there are several, oftentimes mutually-reinforcing, environmental, social and political underlying drivers of local vulnerability which interact with the identified effects of CC, often exacerbating local small-scale farmers' exposure and sensitivity to CC impacts, as well as reducing their adaptive capacity.

The community's history of dispossession and re-settlement, along with its restrictive laws and regulations has left lasting effects on this community. While measures such as the enclosure of farming and grazing land have had a very strong negative impact on the traditional ways of this community, very directly affecting the community's livelihood strategies, the destructive nature and effects of the re-settlement of this community have left significant social scars, creating substantial conflicts within the community, the effects of which are still present today.

A clear example of this is the process of finalization of the land claim process, whose conclusion has not yet been achieved due to the lack of community cohesion and cooperation necessary for crucial decision-making regarding the form of settlement. Apart from restricting the wider community from access to the much needed resources attached to the resolution of this claim, this impasse has contributed to further entrenching already existing community conflict in its various dimensions, i.e., among individual members of the community, between genders and between generations as well.

Ultimately, this internal conflict strongly hinders the functioning of the community as a whole. This is evidenced for example, by the recurrent poor attendance of government-driven workshops and seminars or even by the lack of any sort of community institutions dealing with local community issues identified and mentioned by local government officials and community workers. Perhaps the most vital issue for local small-scale farmers is the local water board. In this case, its absence has unavoidably led to an unequal and unfair distribution of irrigation water, not only negatively affecting the success of the majority of the local farms, but further entrenching internal conflict in the community. This internal conflict also has a very strong negative impact on the social resources necessary for the well-being of the community as whole, and of local small-scale farmers in particular, further limiting their adaptive capacity in relation to CC.

Last but not least are the multifaceted impacts of local farming support, provided mostly by government as the local Department of Agriculture. If on the one hand the poor conditions of Department of Agriculture's mechanisation centre have a negative bearing on the performance of local agricultural production, on the other, the model of agriculture characterised by the use of chemicals and higher running costs which is the foundation for governmental farmer support has imposed a substantially (if not fundamentally) new way of farming in the community. This has had the effect of gradually eroding a lot of the local

farming knowledge, and is particularly relevant in the context of this study, as the absence of this local farming knowledge reduces the local "arsenal" of coping options available, ultimately increasing their sensitivity to CC and limiting their adaptive capacity.

2.3. The effectiveness of the CC coping practices of the small-scale farmers of the Ebenhaeser community

However limiting the abovementioned constraints on their adaptive capacity might be, small-scale farmers of the Ebenhaeser were seen to be taking steps to cope with CC, using their local knowledge bodies to develop various coping practices to respond to the different CC-related hazards.

As predicted in reviewed literature, and despite the abovementioned limiting factors, a significant number of CC coping practices were identified. As also predicted by reviewed literature, most of the CC coping practices mentioned by respondents were directly linked to changes in agricultural practices, and included measures such as shifting planting times of the various income crops, preparing their planting fields well in advance, changing working hours, changing crop options, foresight and planning in terms of livestock nutritional needs, or even manually monitoring soil and weather conditions in search of windows of opportunity.

Farmers also diversified their sources of livelihood by increasing their livestock ownership and increasingly selling more livestock to compensate for loss or lack of income in agriculture. The existence and nature of such coping practices illustrates the continued reliance of local small-scale farmers on their local knowledge as a basis for decision making, showcasing the adaptability and wealth of the local knowledge bodies on which farmers can

still rely. When all else failed, some of the local farmers opted not to farm at all, rather choosing to take on waged-work on large-scale farms in surrounding areas.

Nevertheless, while most of the coping practices being used could be seen as suitable and appropriate long-term coping practices, there are some current coping practices, such as the increased reliance on livestock, or the increased use of agro-chemicals, or even off-farm waged-work, which are not efficient or appropriate for long-term adaptation. In fact, these coping practices could be seen as actually exacerbating the vulnerability of these farmers to CC.

In sum, the various elements of the exposure and sensitivity of the Ebenhaeser small-scale farmers to CC, compounded by their interaction with the identified underlying drivers of vulnerability, highlighted the strong impact of CC on the livelihoods of these farmers.

On the other hand, while devising a series of CC coping practices, the interactions between these practices and the local underlying drivers of vulnerability, have significantly hindered the adaptive capacity of local small-scale farmers. The interactions between these underlying drivers of vulnerability and the local bodies of knowledge used by local farmers in devising CC coping practices have also affected their adaptive capacity. Allied with the fact that to date, other than the apparent shift in the seasons timing and the overall increase in temperatures, no new climate patterns have emerged, these conditions make it hard for the various related local bodies of knowledge to be adapted and used in the most meaningful manner by local small-scale farmers.

3. RESEARCH CONCLUSIONS

Several conclusions could be drawn from the results of this study. First and foremost, the evidence from the field has confirmed the validity of the conceptual framework proposed by the researcher, depicting the dynamic process of development of local knowledge-based CC coping practices by small-scale farmers that forms the main basis for this analysis.

Data analysis revealed that local farmers were not only able to – in line with reviewed literature – identify changes in climate which were hazardous to their livelihoods, but also, as predicted and explained by the proposed model, that they have been developing coping practices in response to the CC.

Additionally, it was identified that a range of underlying drivers of vulnerability pertaining to the specifics of the local physical setting as well as socio-economic and political contexts of the Ebenhaeser community have an important bearing on exposure and sensitivity of local small-scale farmers as well as on their adaptive capacities.

The cumulative nature of local knowledge means that it is naturally adaptable and constantly evolving in response to changing conditions (Kirkland, 2012). In their attempt to respond to the recent environmental changes local small-scale farmers used their local knowledge bodies as a basis for the development of coping practices. Also important is the fact that these local bodies of knowledge were themselves affected by CC.

As these CC coping practices become wide-spread throughout the community, which is ultimately determined by the practices' success in addressing the perceived needs of local small-scale farmers, they (the practices) themselves become extensions of local knowledge bodies. New characteristics of local climate or even pests as they are observed and understood can also become part of the local environmental knowledge of local farmers over

time. Unfortunately, as mentioned previously, the fact that no new patterns have emerged makes it hard for the various related local bodies of knowledge to be adapted and used in the most meaningful manner by local farmers.

This study also revealed the extent to which local social, historic, economic, political and physical conditions influence the sensitivity and adaptive capacity of the small-scale farmers of the Ebenhaeser community. The analysis of the interactions between these underlying drivers' vulnerability and the identified climate-related hazards has revealed that many of the factors that exacerbate the exposure and sensitivity of the livelihoods of local small-scale farmers to CC as well as hindering their adaptive capacity, are in fact originating from such underlying factors. In particular, factors related to the impact of the community's historical context relying on the local natural, physical, and social resources, are at the heart of many of the shortcomings and limitations of local farmers with regard to their CC adaptive capacity.

Other than establishing the link between the historical past of the community and current community issues exacerbating the CC sensitivity and hindering the adaptive capacity of local farmers, the researcher was able to identify another important exacerbating factor on the sensitivity CC and adaptive capacity of these farmers. While the identified gradual soil degradation and an increase in pests and weeds due to changes in the agro-environment are seen as common features of CC (Twomlow, *et* al., 2008; David, 2009; Nelson, 2010: 2), these very features are also common symptoms linked to the use of the chemical model of agriculture (Altieri and Koohafkan, 2008). Although this study could not investigate the overlap between these two sets of features in detail, it is clear from the accounts of local farmers that the impacts of chemical agriculture on soil degradation as well as in the occurrence and severity of pests and weeds related to the chemical model of agriculture exacerbate the effects of CC on local farming systems, and in turn, the livelihoods of local farmers.

The findings of this study not only illustrate the realities of CC and its impacts and the adaptation efforts of small-scale farmers of the Ebenhaeser community, but also open our eyes to those of many other rural farming communities in South Africa. Although each community has its own unique characteristics and history, the South African context is unique in that the same model of oppression that was used in the case of the Ebenhaeser community, was used to guide rural development policy and practice throughout the country, in the lead-up, during, and to a certain extent, even after the *apartheid* era (i.e., land policy, rural and agricultural development models, to name a few). Furthermore, based on the male-dominated nature of gender relations in South Africa, the researcher finds it equally reasonable to assume that this is potentially the case in many other South African rural farming communities.

CC is real and it is here for the long-term. Unless a solution is found which addresses the underlying drivers of vulnerability and their impacts on the key livelihood resources of small-scale farmers, including their local knowledge, in a comprehensive and holistic manner, there is no real prospect of any sort of sustainable, long-term CC adaption solutions for the small-scale farmers of this, and conceivably many more rural communities in South Africa. Ultimately, given the magnitude and importance of CC as a driver of vulnerability, addressing it could be seen as an opportunity to expose some explicit as well as more subtle fractures in the social system, serving as a great unifying factor under whose umbrella many fundamental positive changes in the way we humans interact amongst ourselves as well as with Earth as a system could be achieved.

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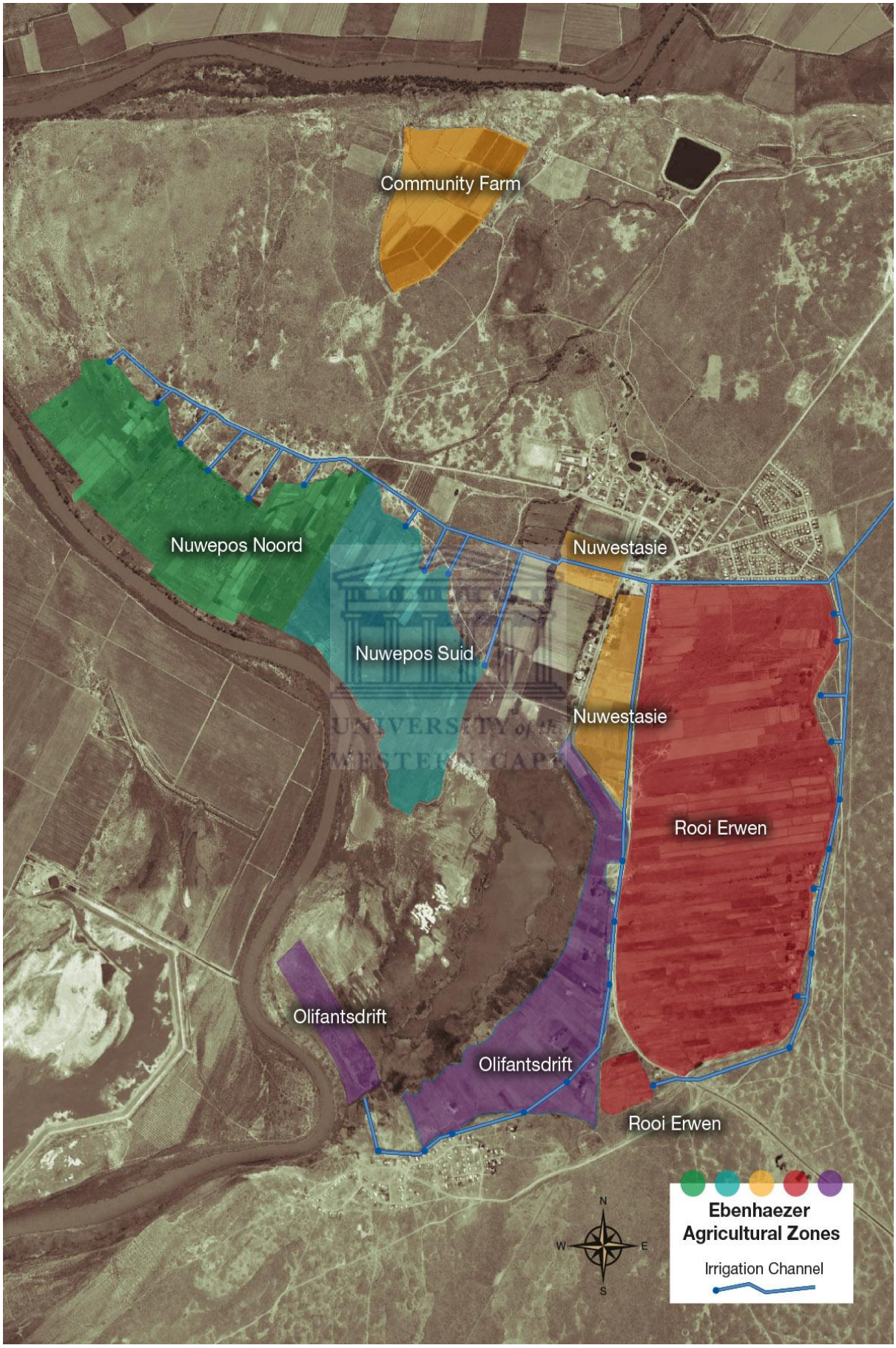
ANNEXURE 1

MAP OF EBENHAESER COMMUNITY



ANNEXURE 2 – INTERVIEW CONSENT FORM

Interview Consent Form University of the Western Cape

Towards understanding the impact of Climate Change on livelihoods, local knowledge and agriculture-based Climate Change coping practices of small-scale farmers of the Ebenhaeser community

Researcher: Mateus Costa Santos

Please initial box

1. I confirm that I have read and understand the information sheet explaining the above research project and I have had the opportunity to ask questions about the project.

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. (If I wish to withdraw I may contact the lead researcher at any time)

3. I understand my responses and personal data will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the reports or publications that result for the research.

4. I agree for the data collected from me to be used in future research.

5. I agree for to take part in the above research project.

_____	_____	_____
Name of Participant (*or legal representative*)	Date	Signature
_____	_____	_____
Name of person taking consent *(If different from lead researcher)*	Date	Signature
_____	_____	_____
Lead Researcher	Date	Signature

(*To be signed and dated in presence of the participant*)

Copies: All participants will receive a copy of the signed and dated version of the consent form and information sheet for themselves. A copy of this will be filed and kept in a secure location for research purposes only.

ANNEXURE 3 – FOCUS GROUP CONSENT FORM

Consent Form – Focus Group Discussions

University of the Western Cape

Towards understanding the impact of Climate Change on livelihoods, local knowledge and agriculture-based Climate Change coping practices of small-scale farmers of the Ebenhaeser community

Researcher: Mateus Costa Santos

Please initial box

6. I confirm that I have read and understand the information sheet explaining the above research project and I have had the opportunity to ask questions about the project.

7. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. (If I wish to withdraw I may contact the lead research at anytime)

8. I understand my responses and personal data will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the reports or publications that result for the research.

9. As a participant of the discussion, I will not discuss or divulge information shared by others in the group or the researcher outside of this group.

10. I agree for the data collected from me to be used in future research.

11. I agree for to take part in the above research project.

_____	_____	_____
Name of Participant (*or legal representative*)	Date	Signature
_____	_____	_____
Name of person taking consent *(If different from lead researcher)*	Date	Signature
_____	_____	_____
Lead Researcher	Date	Signature

(*To be signed and dated in presence of the participant*)

Copies: All participants will receive a copy of the signed and dated version of the consent form and information sheet for themselves. A copy of this will be filed and kept in a secure location for research purposes only.

ANNEXURE 4 –RESEARCH INFORMATION SHEET

Researcher Name: Mateus Costa Santos

University of the Western Cape

Email: santos.c.mateus@gmail.com

Tel: 0795365346

RESEARCH INFORMATION SHEET

Research title: Agriculture-based climate change coping practices among small –scale farmers of the Ebenhaeser community, South Africa

My name is Mateus Costa Santos, student number 3174998 and I am a researcher currently in the process of completing my Masters course in Development Studies at the University of the Western Cape (UWC), in Cape Town. This is a research project being conducted by myself in partial fulfilment of the abovementioned degree in the Institute for Social Development at the University of the Western Cape.

Aim of the study: The general aim of this research is to investigate the impacts of Climate Change on small-scale farmers of the Ebenhaeser community, in particular in relation to its impact on farming practices, local knowledge and the livelihoods of these farmers.

Study outcomes and benefits: The results of this study could be used to better understand the hardships of small-scale farmers in the community in the face of CC, as well as the usefulness and appropriateness of their Climate Change coping practices. Additionally, outcomes of this research may inform policy and interventions to improve the conditions of small-scale farmers in the community and in the country as a whole. You should be aware that although there will be no payments for participating, you will be helping to create a broader awareness of this important issue and perhaps start triggering more effective actions by government.

Your participation: You should be aware that you may find it uncomfortable to share information about your living situation or your income. If this is the case, you have the liberty to not answer such questions. Also, your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized in any way. There are no legal laws binding you to this research.

Research Ethics: The researcher will do her best to keep your personal information confidential. To help protect your confidentiality, your name will be kept anonymous and what you share will be

confidential. This will also be stated before each interview with each participant. Furthermore, the data will be kept in documents which are password protected. A consent form to be signed by the participants will be provided by the researcher detailing these aspects and reassuring the researcher's commitment to protect participant's interests.

Questions about the study: If you have questions or concerns during the time of your participation in this study, or after its completion; or, if you would like to receive a copy of the final aggregate results of this study, please contact:

Researcher: **Mateus Costa Santos**

Email: santos.c.mateus@gmail.com

Tel: 0795365346

Supervisor: **Dr. Lionel Thaver**

Email: lthaver@uwc.ac.za

Tel: 021 9592832

ANNEXURE 5 –INTERVIEW GUIDE

INTERVIEW GUIDE

1. Personal information

- Personal history;
- Nationality;
- Age bracket (15-25; 26-35; 36-50; >51);
- Marital status;
- Employment (self-employed/ employed/ unemployed);
- Education;
- Size of household.

2. For how long have been involved with farming?

3. For how long have you lived in the Ebenhaeser?

4. Do you or your family own land/ livestock in Ebenhaeser? How much land?

5. What crops have you been planting in the latest years? Has that changed overtime?

- For income;
- In the household.

6. What methods have you been using in those activities? Have they changed over time? How so? Are you the only one doing this or is it something that is done by most farmers in the community?

7. Has there been any changes relating to livestock? What changes, and why?

8. Have you noticed any changes in climate since you started farming? What changes?

9. How have these changes affected your farming/livestock/livelihood?

- Farming methods and practices;
- Weed and pest management;
- Water management;
- Knowledge exchanges;
- Others.

10. What have you done to cope with those changes?

11. Did you use your local knowledge to develop those changes or were they introduced by external actors? If yes, what LK was used to inform those decisions? If not, which actors introduced what changes?

12. Are you the only one doing this or is it something that is done by most farmers in the community?

13. How effective were these coping practices in reducing your vulnerability to CC?

14. What is the role of local women in agriculture?

15. Do you have a household food garden?

16. Have there been any changes in the way you maintain household garden over time?

17. Has CC affected your household production? How so?

18. What have you done to cope with those changes?

19. Did you use your local knowledge to develop those changes or were they introduced by external actors? If yes, what LK was used to inform those decisions? If not, which actors introduced what changes?

20. How effective were these coping practices in reducing your vulnerability to CC?

21. Are you the only one doing this or is it something that is done by most farmers in the community?

22. What other problems exist in the community that affect you farming activities?

23. What kind of government support do you receive (if any)?